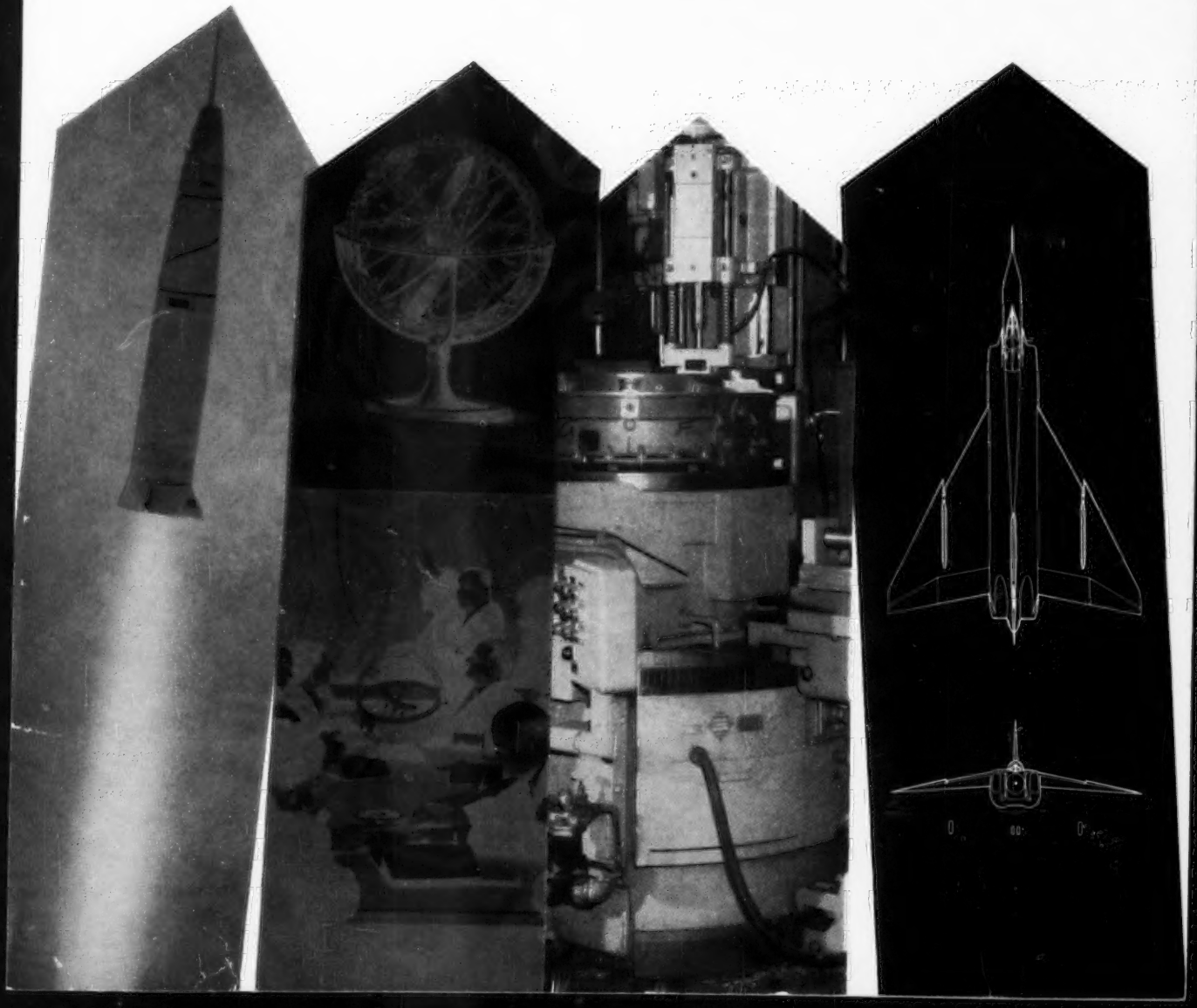
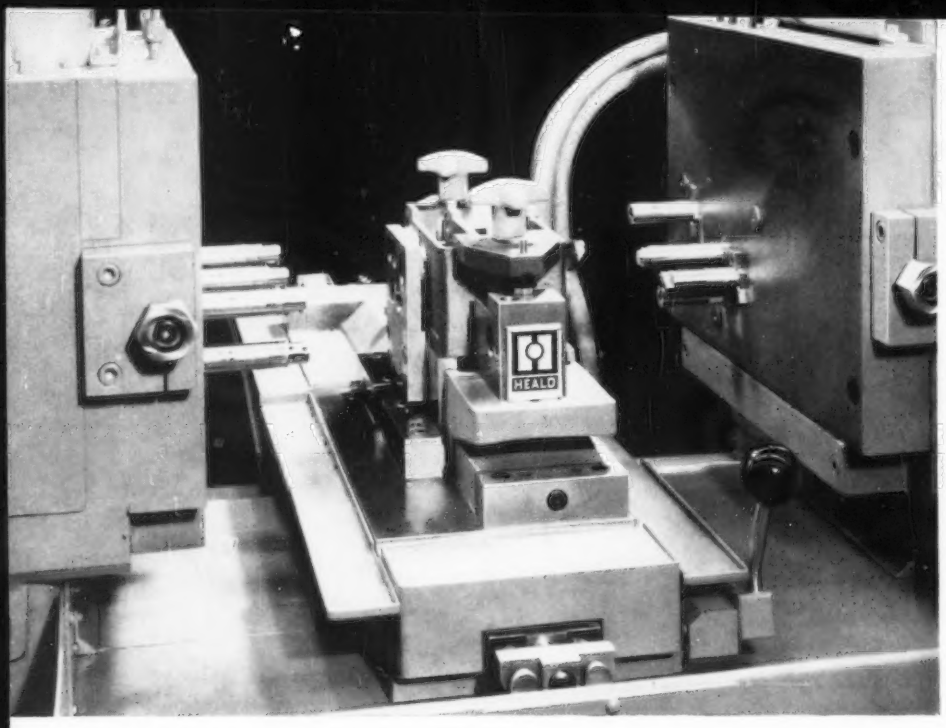
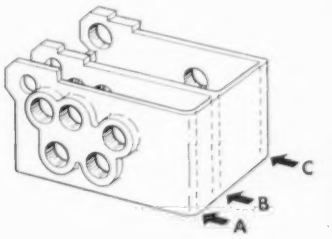
AIRCRAFT AND MISSILES MANUFACTURING

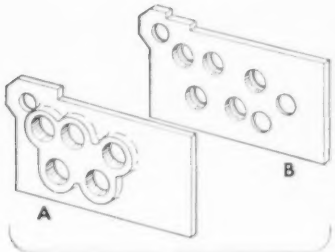
JANUARY 1958

DESIGN PRODUCTION PROCUREMENT

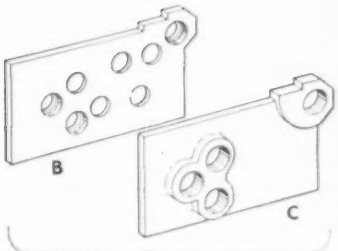








Holes Borized on Left End



Holes Borized on Right End

HOW TO BORIZE

MULTIPLE HOLES

ON CLOSE CENTERS

in one fully-automatic cycle!

New Multi-Spindle Boringheads make it as easy as A, B, C

PRECISION boring of closely-spaced multiple holes used to be a slow and laborious job – done one-at-a-time on large, costly equipment that required highly-skilled operators. But not any more!

The new Heald Multi-Spindle Boringheads put high-precision, close-center borizing on a mass-production basis. Used with any Heald Bore-Matic, this Multi-Spindle head will precision Borize any practical number of holes, on centers as close as ¾", at a single pass of the table – and duplicate the same operation again and again.

A Multi-Spindle head unit consists of a supporting frame which mounts interchangeable spindle plates, precision bored to receive the required number and arrangement of miniature precision Red-Head boringheads.

Any or all boringheads, including the smallest size, ¾", can be provided with hydraulic cross-feed units operated from a single cylinder. Job changeover is simply a matter of switching spindle plates, and mounting the miniature boringheads required.

For the complete story on this important new development, send for Bulletin 2-021-022-1 Issue 1.

HERE'S A GOOD EXAMPLE:

The Model 122 Bore-Matic shown above is equipped with Multi-Spindle Boringheads on both ends, to precision finish close-center bores in a small transmission housing. Each head consists of a group of miniature, precision Red-Head boringheads mounted on spindle plates that are jig bored for precise location of each Red Head. The setup shown, with 5 heads on the left and 4 on the right, is designed to bore and face 17 different holes. All operations are performed in a single, fully automatic cycle, with just one chucking of the work, and no indexing. The surfaces finished at each end of the machine are shown in the "exploded" part drawings above.

IT PAYS TO COME TO HEALD

THE HEALD MACHINE COMPANY

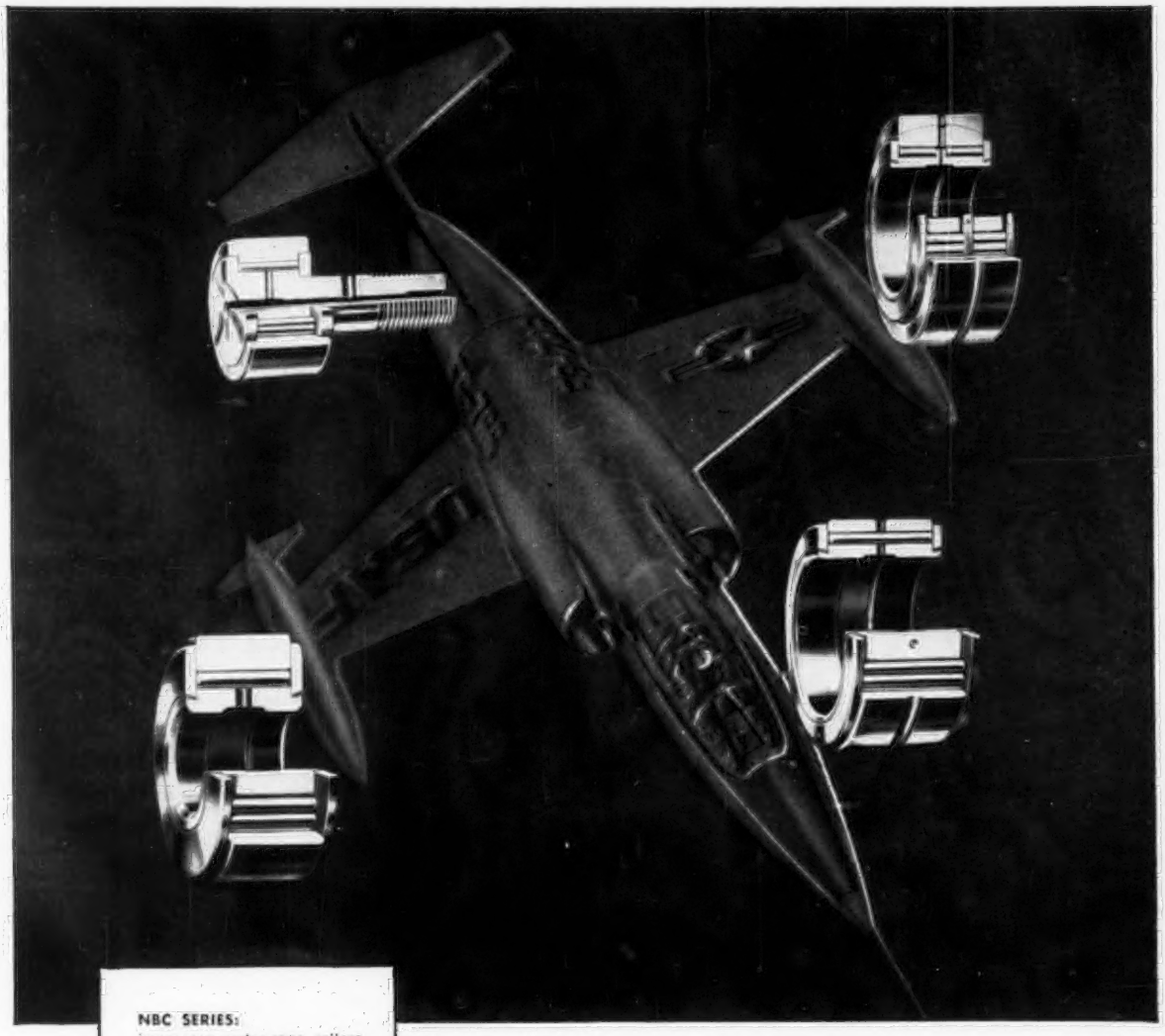
Subsidiary of The Cincinnati Milling Machine Co.

Worcester 6, Massachusetts

Chicago • Cleveland • Dayton • Detroit • Indianapolis • New York

HEALD ®

Circle 61 on Inquiry Card, page 81



NBC SERIES:
inner race, outer race, rollers and end washers securely fastened to inner race.

NBF SERIES:
extra heavy outer race for heavy rolling loads. Also available in double row NBL series.

NBK SERIES:
double row of rollers and self-aligning spherical OD outer race mounted in spherical ID ring.

CR SERIES:
heavy outer race and integral stud permitting cantilever mounting for use as cam or track roller.

Photo shows Lockheed's F-104A Starfighter, world's fastest, most advanced jet fighter, which is equipped with Torrington Aircraft Bearings.

Light for flight...

complete series of high-capacity Torrington Needle Bearings for aircraft application

Torrington Needle Bearings, offering maximum radial capacity in minimum cross section, are ideal for aircraft applications requiring dependable performance with light weight.

Torrington has developed four basic types to cover a complete range of application requirements. All are nonseparable units, made to AFBMA standards, constructed to have low radial clearance when mounted to keep vibration and backlash in mechanisms to a minimum.

Carefully selected quality steels and the most modern manufacturing methods are used in the production of these efficient aircraft-type Needle Bearings. At low unit cost, they bring efficient anti-friction operation for reliable performance and long service life. For further information on their selection and application, just call your nearest Torrington representative or write: THE TORRINGTON COMPANY, Torrington, Conn.—and South Bend 21, Ind.

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS • THRUST

contents

JANUARY 1958

VOLUME 1, NUMBER 1

DESIGN
PRODUCTION
PROCUREMENT

A CHILTON PUBLICATION

THE COVER STORY

Man's efforts to shatter the barriers of Planet Earth form the theme of the cover. Captured by the pen and brush of designer George Samerjan, is the spirit of the struggle to conquer space. From the arrows, we have speed and direction moving toward a round logotype that symbolizes technological progress. Stencil lettering was chosen to display the name of the magazine because it is so familiar an earmark of aircraft and missiles manufacturing.

FEATURES

PAGE

13 Republic's reliability program

19 Bristol/Ferranti Bloodhound

24 production concepts of the CF-105 Arrow

32 SeaMaster part 1

39 numerical control at Lycoming

44 machining honeycomb

48 bonding Convair's 880 wings

50 producing the Electra

62 surface coatings for Vanguard satellite

66 asbestos reinforced plastic

72 silicones for mach 2+

DEPARTMENTS

PAGE

75 producibility review

77 materials and components

80 worth asking for

85 new for production

88 your date book

89 men on the move

99 index to advertisers

INDUSTRY NOTES

91 no rivalry here

91 Hydromatics moves to new plant

91 no second prize in earth satellite race

92 niobium investigated for uses in jets, missiles

93 missile hydraulics problems

94 cermets in russian ICBM?

94 eight reasons for Russia's technological success

98 industry statistics

GEAR OR CRANKCASE
FILLER CAPS

OPEN

Designed to meet the high standards of the aircraft industry, Tedeco Filler Caps are adaptable to a wide range of aviation, automotive and diesel power. They are precision made of pressure die cast aluminum alloy. Available in short or long neck models,—plain or flanged with or without breather vents, dip sticks, strainers, etc.

THEY DO —

1. Snap closed and stay closed
2. Snap open and stay open
3. Provide large, clear opening

THEY DO NOT —

4. Require any tools
5. Get lost or need a rattling chain
6. Look alike open or closed

Tedeco Filler Caps are part of the engineered line of Tedeco Gear Case Accessories.

CLOSED

WRITE FOR OUR CATALOG OF GEAR CASE ACCESSORIES TODAY

TECHNICAL DEVELOPMENT CO.
P. O. BOX 82 • GLENOLDEN, PA.

Circle 65 on Inquiry Card, page 81

GRIEVE-HENDRY
Standard line of 1200° F.
RECIRCULATING OVENS

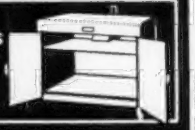
For Solution Heat Treating and Similar Processes

With potentiometer control to meet MIL Specifications.

Full range of sizes for gas or electric heat.

Write for literature.

OTHER STANDARD MODELS
$1105⁰ and up.



GRIEVE-HENDRY CO., INC.
1416 W. Carroll Avenue, Chicago 7, Illinois
Export Dept., 10406 S. Western Ave., Chicago 43, Illinois

Circle 66 on Inquiry Card, page 81

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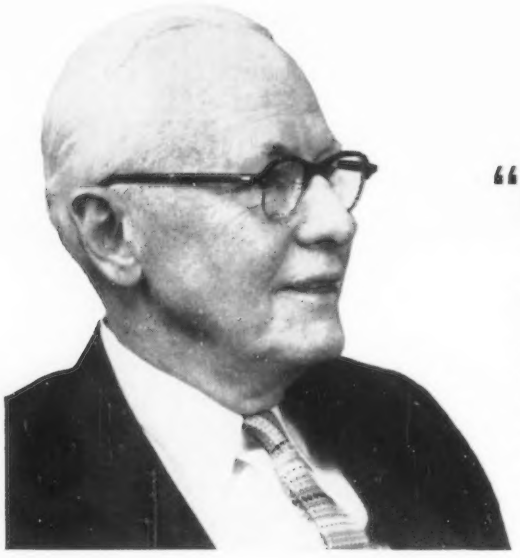


"industrial publications have

For all of the 37 years since he left Officers' Training Camp at the close of World War I, Reed Schreiner has been in steel. Seven years ago he became Director of Advertising for the United States Steel Corporation, a position for which he qualified by serving the Corporation and its various subsidiaries in many capacities from copywriter to Assistant Director of Advertising. We recently visited Mr. Schreiner in his Pittsburgh office to learn something about his philosophy and experience in the use of business publications. Here are the highlights of our long and pleasant talk with this seasoned advertiser.

Q Tell me, Mr. Schreiner, just how many years has your corporation been advertising?

A I'm afraid that's a question that cannot be answered without considerable research. This corporation is the sum total of many different organizations whose advertising histories are obscured by time. I think I can best answer your question by saying that we've been at it for a long, long time.

Q I'm certain that the record reveals many interesting highlights and advertising firsts. Among them, what do you consider to be of particular interest?

A Well, one advertising first that immediately occurs to me is the fact that we were among the very first, possibly the first, to use the cartoon technique in industrial advertising.

Q And that was how long ago?

A Offhand, I'd say about 1930.

Q And how about a highlight from your postwar advertising activities?

A Well, as you perhaps already know, we were the first basic material producer to promote the products of our cus-.omers in the consumer market on an industry-wide basis. By that I mean we promote the use of steel, not just U.S. Steel, with the firm belief that we will get our fair share of the steel business created.

Q That is very interesting. Tell me, did you use business publications for this undertaking?

A Yes, we did and still do. And very extensively, I might add.

Q Just what is your philosophy in respect to business publications, Mr. Schreiner?

A We regard them as a vital link in our chain of communications. Properly used, they contribute importantly toward the attainment of our sales objectives. We know of no better way to reach industrial buying influences economically and efficiently.

Q Approximately how many business publications do you use?

A Something more than 300.

Q What percentage of your space budget goes into business publication advertising?

A About 28%. And you will be interested to know that this represents the largest single expenditure in our advertising budget.

Q For what specific purposes do you use business publications?

A I would say that we have two basic reasons. The first, of course, is to reach the many and varied buying influences in which we have an interest. The second is to conserve the time of our salesmen.

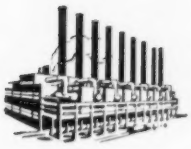
Q With a product and organization such as you have, your salesmen certainly do not have to overcome the more common obstacles, Mr. Schreiner. Just how, then, does business publication advertising help conserve their time?

A In many ways, but I'll illustrate just

one. Not very long ago we developed and introduced a new constructional alloy steel, and we advertised this fact in appropriate business publications. Our salesmen reported that as a result, they generally found the customer familiar with the new product and eager to discuss it. In a word, the advertising had done the spadework for the salesman—had saved him the time it would have taken to introduce this product to an unconditioned prospect.

Q What, in general, do your salespeople have to say about your use of business publications?

A I think their opinion about the value of business publications is best evidenced by the fact that they are constantly after us here in Advertising to do more and more—to add publications, to increase our use of those we are already in.



leadership responsibility to their industries"

Q What do you think the average reader looks for principally in a business publication?

A For information pertinent to his particular industry, for trade news, for a report on new developments and new products which may directly or indirectly affect him. But more importantly, I think he looks for an accurate, impartial interpretation and analysis of the news and developments within the

industry. It is for this reason that I say business publications have leadership responsibility to their respective industries. Not only do they help the reader do a better job today, but very often they have a definite influence on his personal development and growth within an industry.

Q What general rule or rules do you apply to the preparation of advertisements in business publications?

A We firmly believe in factual information advertising that features the merits of our products without reference to competitive products.

Q Do you feel that advertisements are important to the reader of a business publication?

A Indeed I do. Not so long ago, we asked a group of some 250 busy officials in various industries whether or not they would prefer the business publications they regularly read to carry no advertising. While I am not at all surprised at the outcome, I am surprised by the one-sidedness of the attitude revealed—96% said the elimination of advertising would be highly undesirable.

Q Do you feel that business publications are increasing in importance?

A Definitely. New developments are coming along so fast, and business is becoming so complex, that the need for the many services rendered by business publications is greater than ever before.

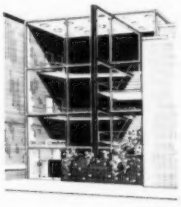
Q What are your criteria for the selection of a business publication?

A In general terms we look for the publications having acceptance within an industry. We naturally consider such important factors as editorial content, circulation, and selling power, but if you find evidence of high reader acceptance you can be certain that all the other considerations are in line.

★ ★ ★

Modern business publications are the all-important link between you and the buying influences you want to reach. They provide the means for reaching your prospects and customers on common ground—at a time when they are receptive to your sales message. In this respect, business publications fill a role unduplicated by any other known selling force.

Chilton publications cover their fields with an editorial excellence and a quality of circulation that assure confidence on the part of readers and advertisers. With such acceptance goes a proportionate selling power. Let Chilton publications help give your advertising maximum effectiveness.



Chilton
COMPANY

Chestnut and 56th Streets • Philadelphia 39, Pennsylvania

CHILTON PUBLICATIONS: The Iron Age • Department Store Economist • Spectator Hardware Age • Hardware World • Jewelers' Circular-Keystone • Motor Age Automotive Industries • Distribution Age • Optical Journal and Review of Optometry Boot and Shoe Recorder • Commercial Car Journal • Butane-Propane News Gas • Electronic Industries • Aircraft & Missiles Manufacturing • Book Division

AIRCRAFT
AND MISSILES
MANUFACTURING

manned by an electronic brain

. . . but it takes humans to design and manufacture the uncanny Nike missile. And Aircraft and Missiles Manufacturing fulfills the human need for sifted-out, concentrated data, gathered in one publication for this specific purpose.

That's the whole purpose of the new Chilton publication, A&MM. It provides essential information in detail on such subjects as metals and alloys, new design applications, production techniques, component reliability. All sorely needed by practical design engineers, production and procurement executives.

We asked the men you want to sell...

In a nationwide personal interview survey, aircraft and missile manufacturing men said the facts that they sought were hard to find—a bit here—a bit there—in general industrial and metal working magazines—in production publications—in small segments of aircraft books. And they said that general news about the aircraft and missile business was not enough. They need "down-to-earth" information to design and build operational units from theoretical dreams.

Now A&MM answers the marketing problem

A&MM reaches a carefully screened group of over 15,000 manufacturing personnel, selected because they have practical specifying and buying powers. A&MM reaches the manufacturers of aircraft and missiles as well as the manufacturers of accessories, parts, components and sub-assemblies.

Circulation is directed to: the men in engineering concerned with "design for producibility" (45%); the key men in production responsible for tooling, welding, forming, finishing quality control, materials handling, assembly and component installation, et. al. (45%)—plus procurement and administrative men (10%).

Editorial aimed at the men you must sell

Solid editorial matter that practical missile and aircraft men *must* read to do a better job. A&MM fills the wide gap between general publications that have a sprinkling of content of interest to these men and the aircraft and missiles publications that offer little in the way of practical design and production. A&MM will publish the first adequate coverage of such industry subjects as: "Design for Producibility", "Ramjet Combustion", "Design for Safety", and "Materials for Future Design".

Remember, *if you want to reach over 15,000 men actually responsible for building aircraft, missiles and components—the men who specify and buy—you can reach them best in AIRCRAFT AND MISSILES MANUFACTURING.*

AIRCRAFT AND MISSILES MANUFACTURING

A Chilton Publication, 56 & Chestnut Streets, Philadelphia 39, Pa.

Illustration courtesy of Eastern Industries, Inc., manufacturers of aviation pumps, electronic cooling and refrigeration units, pressurization units, and hydraulic power units.

SHEET METAL FABRICATION for AIRCRAFT

United Aircraft Products, Inc. offers immediate scheduling for the production of aluminum, stainless steel, titanium and magnesium sheet metal assemblies in our new 90-thousand sq. ft. modern plant. This newly acquired UAP facility has been furnished with the latest equipment for welding, brazing, machining and assembling of components to aircraft quality requirements —test and inspection facilities—resident Air Force inspectors. Shipping facilities include motor transport, rail spur and air freight.

IF YOU HAVE A NEED FOR HIGH PRECISION—MEDIUM TO HIGH VOLUME SHEET METAL FABRICATING FACILITIES, PLEASE CALL THE NEAREST UAP CONTRACTUAL ENGINEERING OFFICE.

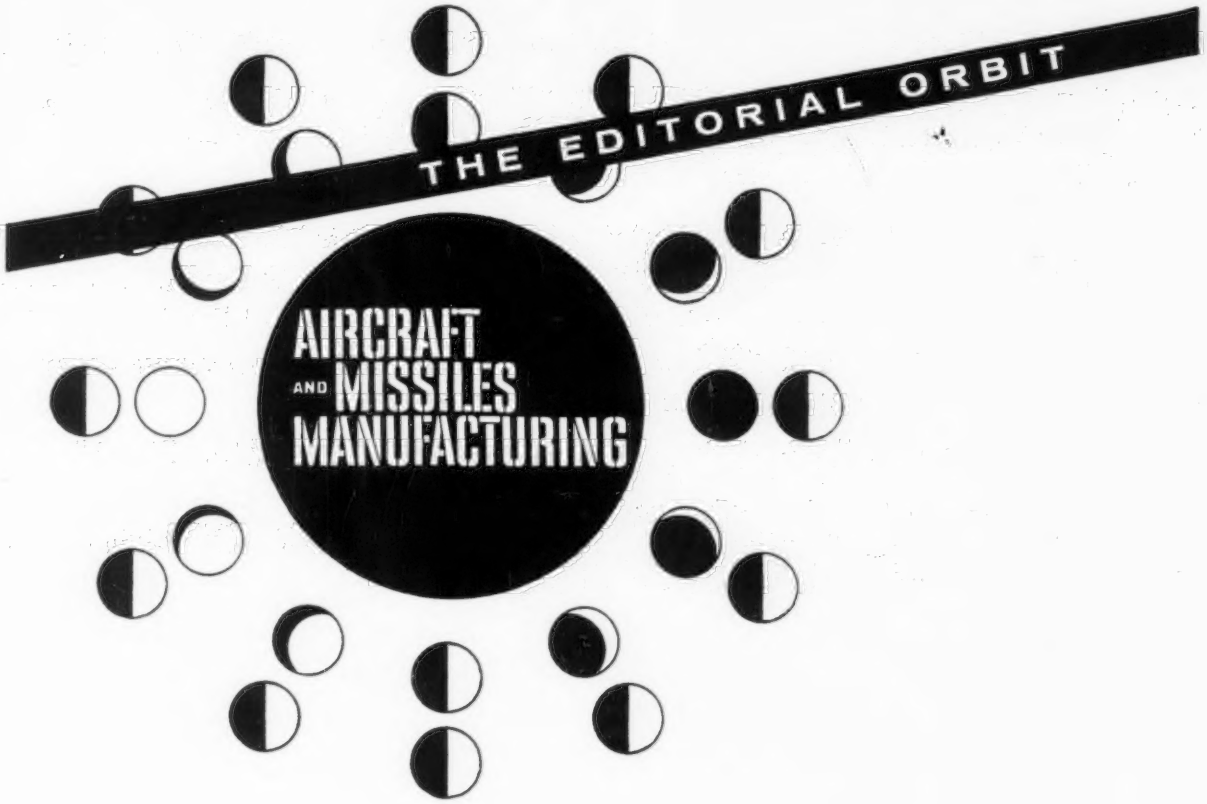
DAYTON • 1116 Bolander Ave. • Dayton, Ohio..... BA 4-3841
CALIFORNIA • 1101 Chestnut St. • Burbank, Calif..... VI 9-4236
NEW YORK • 50 E. 42nd St. • New York 17, N. Y..... MU 7-1283
CANADA • United Aircraft Products, Ltd.....5257 Queen Mary Road
Montreal, Canada.....ELmwood 4131

UAP

a famous family of aircraft essentials since 1929

UNITED AIRCRAFT PRODUCTS, INC.
1116 BOLANDER AVENUE, DAYTON, OHIO

Circle 67 on Inquiry Card, page 81



five – four – three – two – one – zero

THIS IS IT! Our project, Aircraft and Missiles Manufacturing (AMM), is off the ground and we're heading straight for design and production engineers. One of our major objectives is to provide a means of better communication within the aircraft and missile industry, and particularly between the design and production groups. On these pages, you'll get practical engineering — the kind that builds for inventory.

Feature articles will give you the facts on design, production, and materials in all phases of the aircraft and missiles manufacturing industry. You'll get case histories and cost figures when feasible.

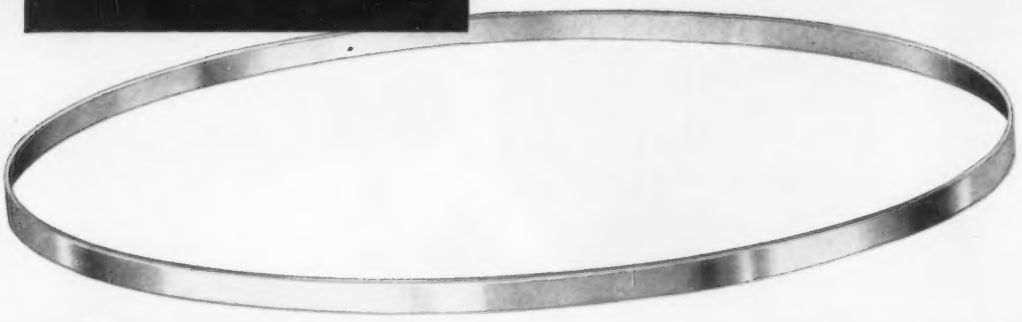
You'll find that AMM will take a firm stand on certain national policies; we firmly believe that politics has no place in the aircraft and missile manufacturing industry.

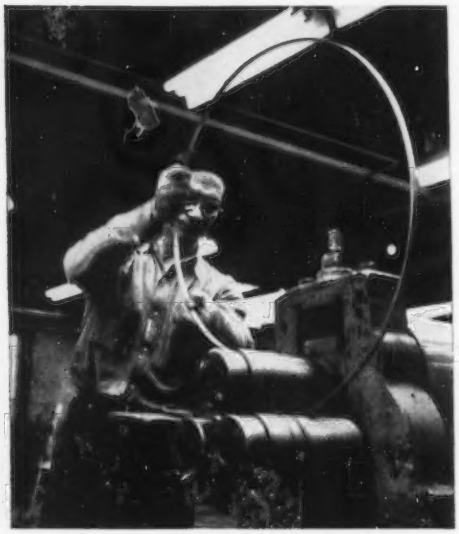
I could spend a lot of time here telling you about this first issue, but it would be much better to let you evaluate it.

Remember, you are on my Board of Directors. Let me know what you want and how often you want it. I want your comments, not just on this first issue, but on every issue. In return, we're going to do our very best to help you in your job. And, above all, to help make sure that your efforts and achievements in the aircraft and missile manufacturing industry are given proper national recognition.

Editor

Precision Rings with little or no machining





Today you can purchase precision flash butt-welded rings that require little or no machining to meet your specifications. Made from bar stock of finished gauge, they can be produced to meet the same tolerances as conventionally machined rings. Cost of production and materials of some rings has been reduced as much as 60%. Sizes and materials at present are limited to those bar stocks which can be furnished to precise finished dimensions. However, persistent efforts of American Welding engineers and the producers of finished bars give promise of a widening range of sizes and metals that can be manufactured by precision forming and welding.

This is another example of why you should call American Welding first — if the problem is circular and of metal.

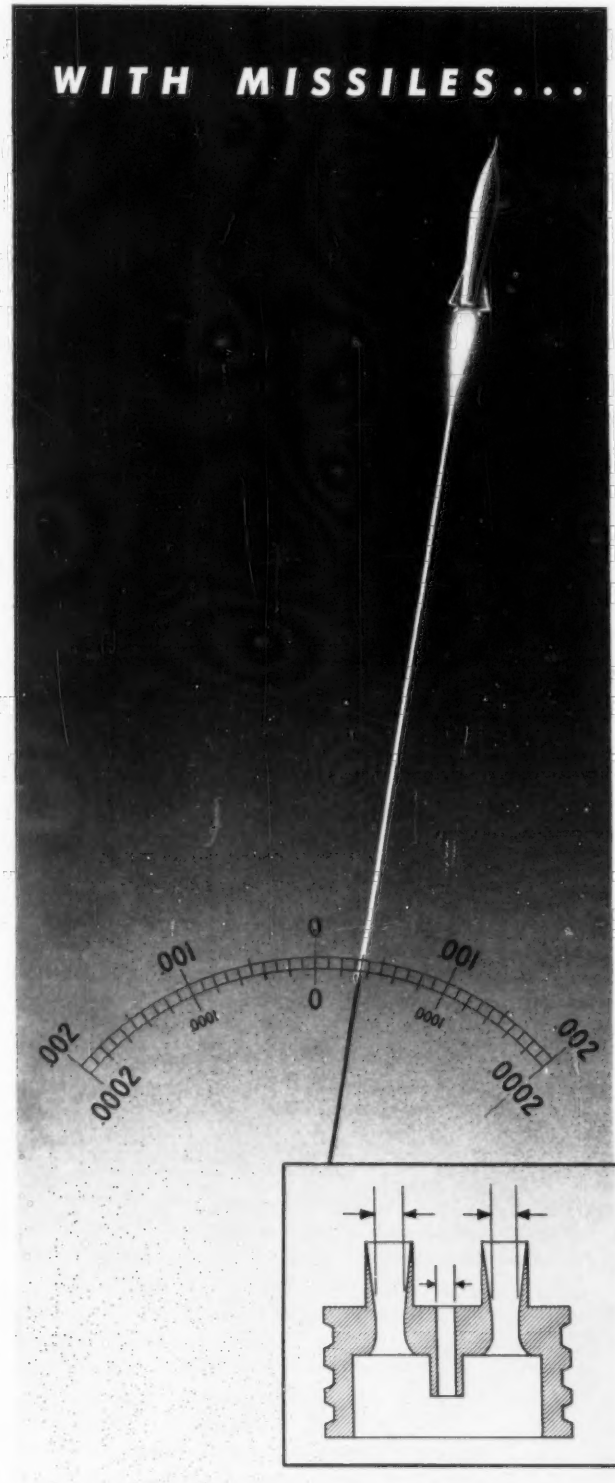
New Products Catalog

Write today for 20-page catalog of circular products which American Welding can form, weld and machine for you.

AMERICAN WELDING

THE AMERICAN WELDING & MANUFACTURING CO.
552 DIETZ ROAD • WARREN, OHIO

Circle 69 on Inquiry Card, page 81



SO MUCH DEPENDS ON PRECISION GAGING

it pays to rely on —

FEDERAL

Precise control over dimensional accuracy of missile parts and components is an acknowledged necessity. Whether the machined part must be accurate to .001" or .000010", its conformity to size must be known with unquestionable certainty.

Supplying gages that provide high-order precision and dependability calls for special engineering experience and skill, plus a full understanding of the unusual problems involved. Over thirty-five years' experience and 30,000 successful gage designs, many of them for missile contractors and sub-contractors, proves that Federal has these qualifications. Whether you need one gage or a whole gaging program, Federal's experience in gages and gaging programs for missiles can pay off in safeguarding your productive effectiveness.

Only Federal has four different systems of gaging from which to impartially select the one best suited to your needs — another reason why Federal has more to offer in precision measurement.

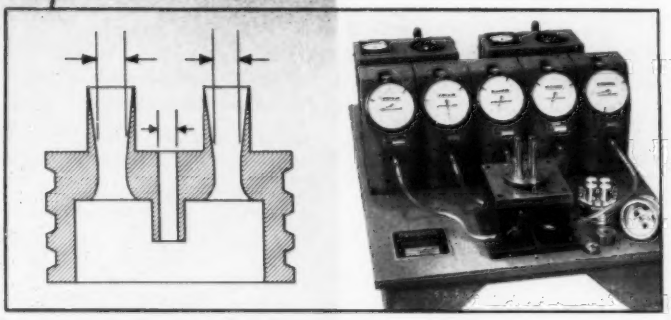
We're ready to offer you precision gaging ideas which have been so successful for other producers of missile parts and components.

Write us concerning your needs.

FEDERAL PRODUCTS CORPORATION
8461 Eddy Street **Providence 1, R. I.**

FEDERAL has supplied precision gaging for: —

- **NIKE**
- **CORPORAL**
- **ATLAS**
- **DART**
- **SPARROW**
- **MATADOR**
- **FALCON**
- **FIREBEE**
- **NAVAHO**



FOUR NOZZLE DIAMETERS CHECKED SIMULTANEOUSLY
Multi-unit air gage (Dimension-air) uses four contact-type air plugs to check diameter of land in nozzles (tolerance ±.0005"). Regular air plug checks centrally located bore (tolerance ±.0002"). Nozzle assemblies and masters shown on gage platform.
(Other missile gaging applications to .000010" accuracies.)

Ask **FEDERAL** *First*

FOR RECOMMENDATIONS IN MODERN GAGES . . .

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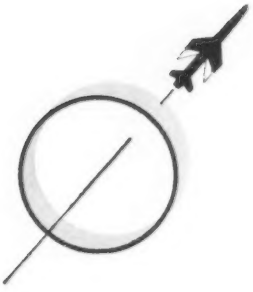

Since the mid-forties, top scientists in the United States have been working on the missiles problem. Would it surprise you to know that, in many divisions of missilry, we have out-distanced the Soviet?

At the moment this superiority may not seem important because of our "wrong alley" approach. Until Sputnik, we had been thinking of missiles as part of ordnance: ground to air or air to air *defense* weapons against invading aircraft.

Not so suddenly, the Soviet stole the march and invested missiles with an aura of finality, of ultimate scientific achievement.

We suggest that today's Thors, Vanguards, Jupiters, Titans and Atlases are, to the missiles age, what Kitty Hawk was to aircraft. New materials, new propellants, new IDEAS may shortly make 1958 models of missiles look like the Wright Brothers' plane.

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Republic's reliability program

using operational statistics agency reveals clues for improvement of product

by Charles W. Russell, Chief Reliability Engineer, Republic Aircraft Corp.

In the past few years the increased cost and complexity of modern weapons, coupled with a limited budget, has required the military services to procure and maintain fewer airplanes. To reduce the quantity of airplanes without weakening the country's defense, the same "combat potential" must be maintained with less aircraft. To do this a greater effort must be made to insure the maximum reliability of all weapon systems. Republic Aviation Corp. recently started a program to insure the highest degree of reliability in its products.

To appraise this program the problems must be clearly defined. At Republic, reliability is the high level of probability that an aircraft or missile will perform its design function under specific conditions over a definite period of time. In other words, it will work when it is required to do so. It has always been the responsibility and interest of the aircraft industry to build a reliable product. However, the complications and high cost of aircraft design and construction have made it necessary to have a group to devote full time to the problems of reliability. The cost of such a program today is cheaper than the price paid for the lack of it.

Republic followed a similar concept when its Design Safety Program, the first in the industry, was initiated in 1946. The function of the Design Safety group was to analyze design from the standpoint of safety. The operation of this group accentuated the need for a reliability program.

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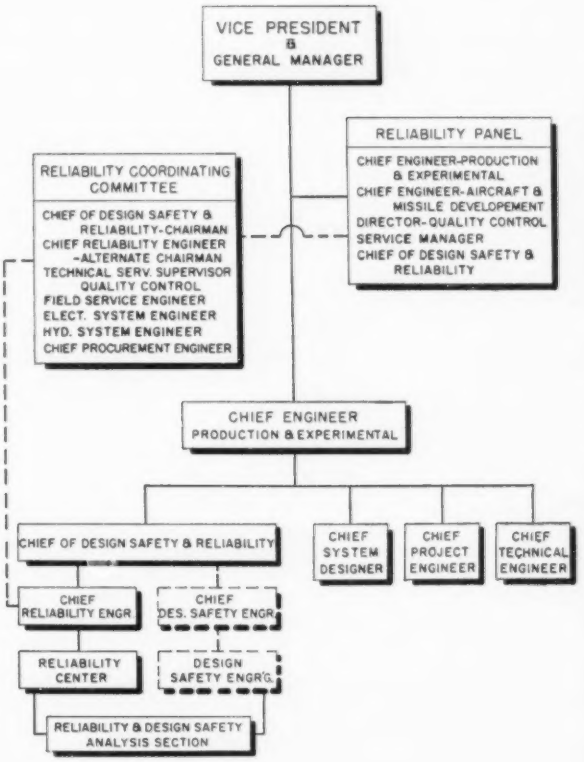
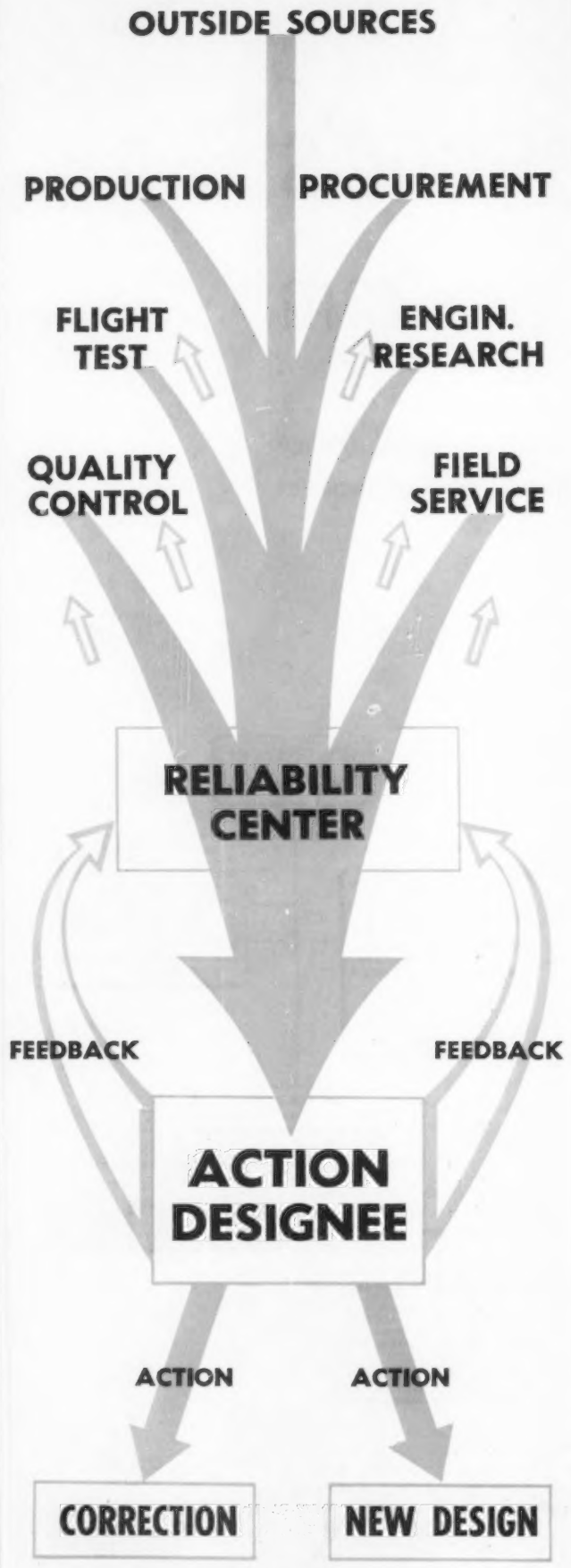


Fig. 1: Table of organization showing the extensive scope of Republic's Reliability Program.



Republic's reliability program

Panel for Reliability

A reliability program should be given top management approval, sanction, and support. At Republic it was initiated by the vice-president and general manager at a meeting of key supervisory personnel from all departments. Objectives of the program were outlined and its importance to management was emphasized. The reliability organization at Republic is shown in Fig. 1. As indicated by this chart, the program has the blessing of top management through their active participation at regular meetings of the Reliability Panel. This panel has been formed as the highest echelon in the program. Members include the chief engineer for production and experimental, chief engineer for aircraft and missile development, director of quality control, field service manager, and chief of design safety and reliability. The factory manager, director of weapon systems requirements, and the director of materials are stand-by members of the panel.

The Reliability Panel functions as the top coordinating group and reports to the vice-president and general manager. It serves primarily as a policy making group and provides overall surveillance of the program. Since the program cuts across every major field of aircraft and missile manufacturing (engineering, production, procurement, field service, quality control) the panel serves an important function in coordinating the activities of the groups and settling items of controversial nature. Inter-departmental education and training in the field of reliability is one of its responsibilities.

A Reliability Coordinating Committee functions with members from engineering, field service, quality control, and procurement. The Committee serves primarily as a coordinating group among the participating departments. The Committee resolves most of the controversial problems concerning reliability and test requirements. Unresolved problems are submitted to the panel for solution. The Committee meets regularly and sends minutes of each meeting to its members, the Reliability Panel, and all interested departments.

Hub of the Program

The work-horse of the program is the Reliability Center. This group functions in the engineering department under the chief reliability engineer, who reports to the chief-design safety and reliability, and has the responsibility

◀ Fig. 2: Trouble report flow through Reliabiilty Center.

of serving the Panel and Committee by providing them with all necessary data and reports.

The areas of the program covered by this group include:

1. Collecting and analyzing discrepancies, failure and malfunction reports from all departments within the company, and maintaining an IBM punch card record on these items. A new trouble report form is being used on a trial basis at several Air Force bases and test centers. This report will provide the Center with statistical data required for better analyses. Comments from field service personnel will be evaluated in establishing the final report form. All parts have been coded for IBM filing and will be recorded as the reports are received. Reports on items requiring corrective action are referred to the proper department and each request is followed up to determine what action has been taken.

2. Collecting data on malfunctions and reliability from the Air Force, Navy, vendors, other airframe manufacturers, etc., and dissemination to all affected groups. In addition to the statistical records on all components and systems, the Center maintains a preferred products list of sub-components such as: resistors, condensers, tubes, etc.

3. Supplying information on failures, general reliability factor equations, methods, etc., to the design section for reliability analyses, and providing assistance in these analyses.

4. Aiding in the selection and control of vendors by providing statistical data on manufacturers to the engineering and procurement departments.

5. Assisting in the development of reliability requirements for procurement and test specifications.

6. Handling details required for training and education in reliability, throughout the company.

7. Providing the military services with a prediction of the overall reliability of the aircraft and/or missile being produced, when sufficient statistical data are available.

Coordination through this central group is the key to effective implementation of the program. The flow chart, Fig. 2, shows how the Center acts as the receiving and disseminating agency. Items which appear insignificant by themselves may indicate a trend when studied in conjunction with other reports from different departments. Without the Central group to collect and analyze discrepancies from all departments, significance of failures and malfunctions could be easily overlooked.

Criteria for qualification and acceptance testing are still formulated by engineering, in conjunction with quality control. However, conditions covering operating limitations, environment, and applicability of qualification and acceptance tests are analyzed by the Reliability Center, and recommendations are made for improvement, when required. The established criteria are applicable not only to components being procured under Republic specifications, but also to standard parts.

Corrective Action

A deficiency correction system on flight safety hazards has been in use by the Design Safety Group for the past 10 years. By expanding the scope of this system to cover all deficient areas, the additional needs of the Reliability Group are adequately served. When the analysis of deficiencies indicates that corrective action is necessary, the item in question is referred to the affected project or systems engineering group, and a follow-up is maintained by the Center.

A primary function of the trouble reporting system is the feed-back of information from the Center to the originating groups. As the reports are submitted to the Center, each item is immediately coded on IBM punch cards and analyzed for appropriate action. When corrective action has been determined, the Center notifies the originator of the trouble report.

Everyone Involved

Reliability is the responsibility of all departments. Regardless of how reliability is designed into the system, if some other department is unable to perform its function properly the final product will be adversely affected. If, for example, manufacturing cannot make a part or install a system correctly with good shop procedures, reliability in operation will suffer. In this program the solutions to the above problems are as important as design considerations.

How the System Works

A trouble report (Fig. 3) indicating the replacement of a component comes in to the Reliability Center from an Air Force Base.

The information is analyzed by the Center and coded on an IBM code transmittal sheet, and submitted to the IBM section with a request that all cards indicating malfunction of this unit be sorted and returned to the Center.

Analyzing these cards, the Center finds

that there has been "x" number of similar instances from other bases. Manufacturing has also reported "y" number of replacements in final assembly. A follow-up form (Fig. 4) is then filled out and submitted to the Action Designee (group responsible) denoting number and type of failures and requesting an investigation of the problem. Within 10 days, the Action Designee notifies the Center of its findings, and of the issuance of new instructions to overcome the difficulty. The Center, when satisfied that there has been a proper fix, notifies the originator of the trouble report of the action that is being taken.

Avoiding Backlog

In a system of this type, it is essential to avoid accumulation of a large backlog of raw data. Uncoded data serve no useful purpose and can have an adverse effect on the attitude of the people submitting the reports. Prior to the institution of the trouble reporting system, data were collected, hand sorted, and tabulated. Analyzing these data for significant trends was a time-consuming problem. With the IBM process it is easy to have up-to-date information coded and available at all times.

Collection Agency

In addition, the Reliability Center operating as a central agency has considerable advantage in collecting data from outside sources. Through agreements made with the reliability groups of other manufacturers and Government agencies, the free exchange of information and ideas results in a substantial supplement to the data collected at Republic.

A member of the Reliability Center represents the company on the A. I. A. Product Improvement Program Panel of the Engineering Contracts Requirements Committee. Additional data from other companies are obtained on a cooperative basis both through the formal activities of the panel, and by contact with panel members of other manufacturers. Presently closely working liaison system is being established with all Air Force activities involving reliability and product improvement programs.

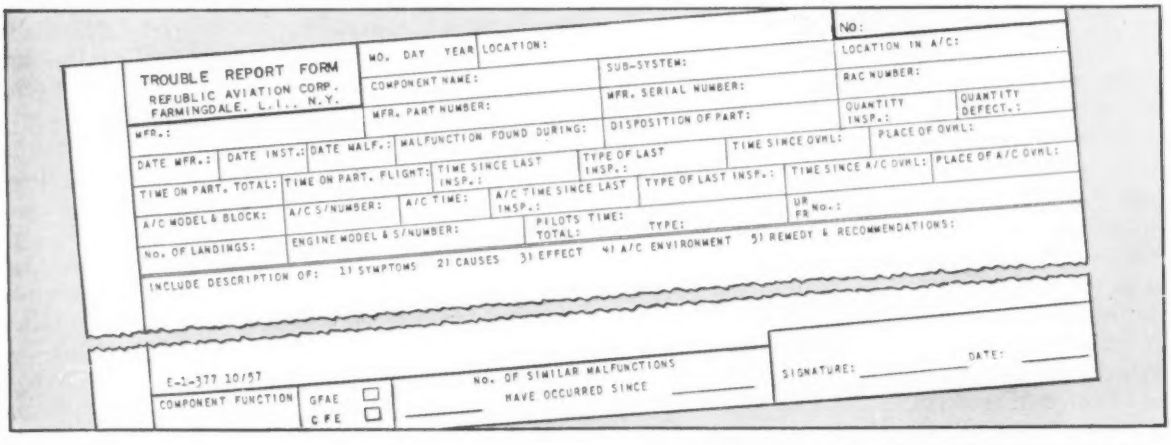
Inherent to Design

Reliability is an inherent part of a system design, and cannot be isolated from other design considerations. The preparation of procedures for the analysis of systems and sub-systems is a function of the reliability group, while the preparation of such analyses is a basic function of the systems engineers. The Center cooperates fully with the systems engineers in each analysis, and contributes to the determination of environmental conditions. An established program is utilized to check actual conditions at as early a stage of flight testing as possible, with a re-evaluation of qualification and acceptance tests being made as necessary.

Advantages

Although the reliability program at Republic is still young, definite advantages have already been realized which confirm its value and need.

Fig. 3: Such forms used for reporting individual cases of malfunction help piece together possible patterns of trouble.



For instance, statistical analysis showed that some of the hydraulic hoses of a certain type were subject to seepage. Although this seepage was insufficient to constitute a definite threat to safety, the hoses were constantly being changed. It was known that approved hoses of an improved design had recently been made available. Investigation showed that the cost of changing to the new hoses was insignificant as compared with the cost of the delay caused in the flight test program by the constant maintenance of old hoses.

Had the reliability program not been in operation, each instance of hose seepage could have been considered an isolated case; this hose would have been replaced from existing inventory until the inventory was used up and then, at some future time, the improved hose would have been installed. Because the reliability program did focus attention on the true nature of this problem prompt remedial action became possible.

In another case, through a statistical trouble report analysis, it was noted that the landing gear warning lights came on during flight (indicating an unsafe condition of the gear) too frequently.

Checking and readjusting switches met with no success. Intermittent occurrences were still observed in flight.

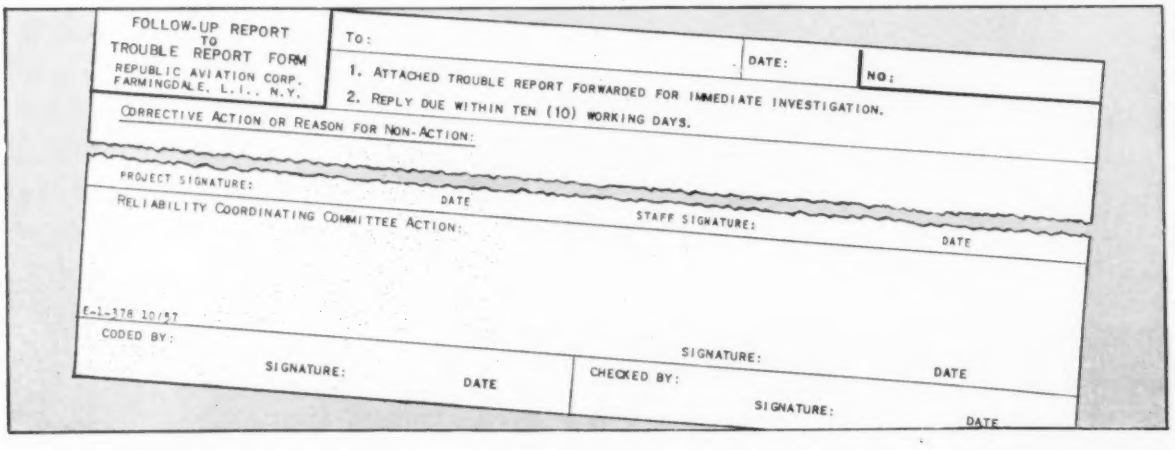
Study of films showed the lower surface of the wing on one flight, indicated that under a negative "g" condition the landing gear doors were gapping. Without a recorded cumulative history of the warning lights, this also could have been construed as an isolated case and attributed to poor rigging of the doors on this particular airplane. However, previous reports indicated that the door gapping was a problem from the start, and immediate action was taken to correct the condition.

The advantages of a reliability program was more evident now, than when the program was originally instituted. In some areas it was at first felt that although an ultimate reduction in the cost of maintenance and procurement, by the Air Force, might result from this program, it may also mean a substantial increase in the cost of the product. Republic, however, does not feel that such is the case. Many components are qualified for acceptance under "standard" tests which in many cases do not qualify the component for use under actual operating conditions. Substitution of these tests by more realistic ones—devised by the Reliability Center—are expected to give a better overall product without substantially increasing its cost. Also with data and statistics as tools in the designers hands, many potential costly redesigns and consequent schedule delays may be avoided.

If in some instances an increase in the cost of the product incurred, it would be more than off-set by savings realized by the Air Force, through the resulting reduction in the cost of maintenance.

Even more important than the cost consideration is the vital necessity for an aircraft or missile to perform its mission reliably when called upon to do so.

Fig 4: Follow-up report form for corrective action makes certain that no case of malfunction is inadvertently overlooked.



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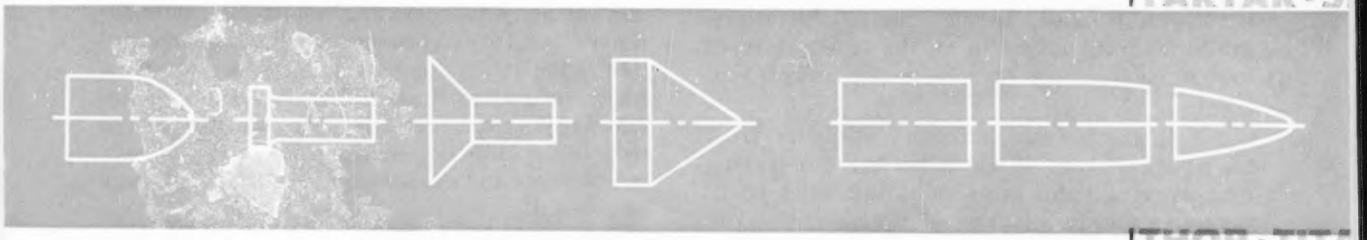

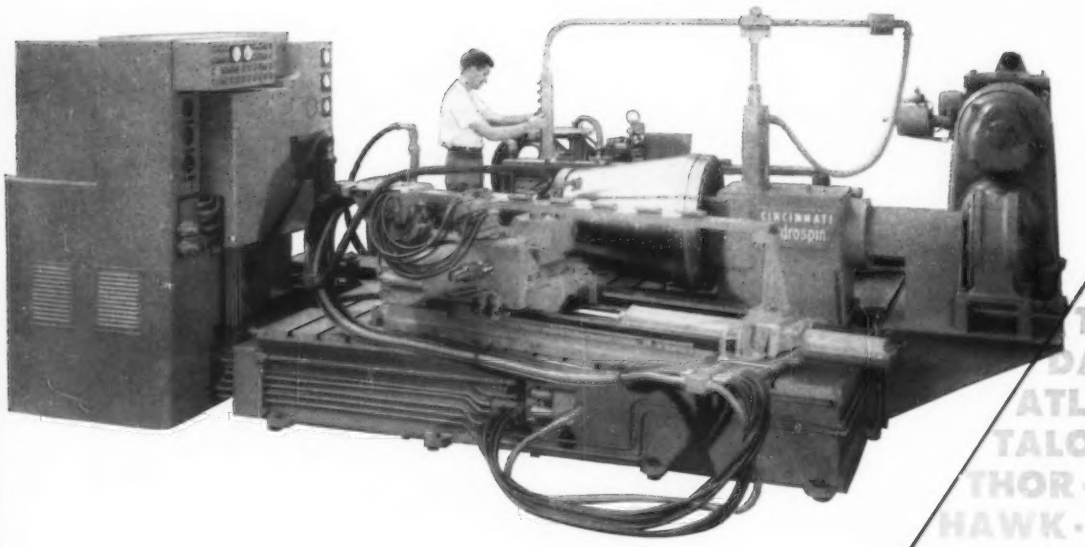

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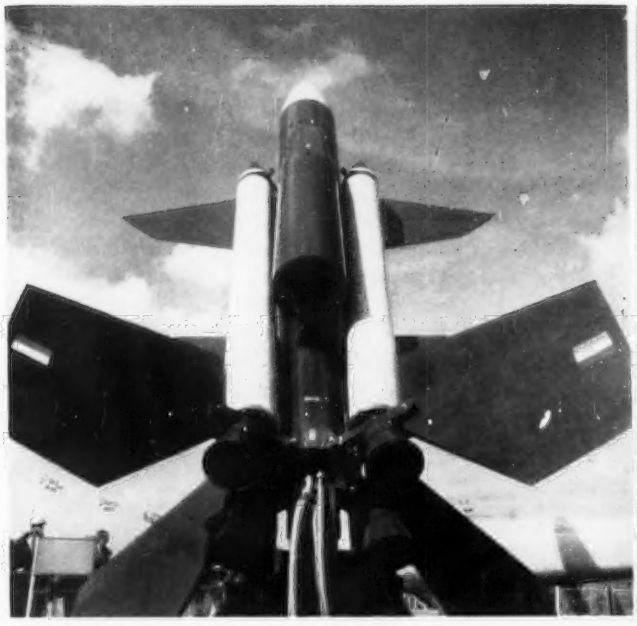
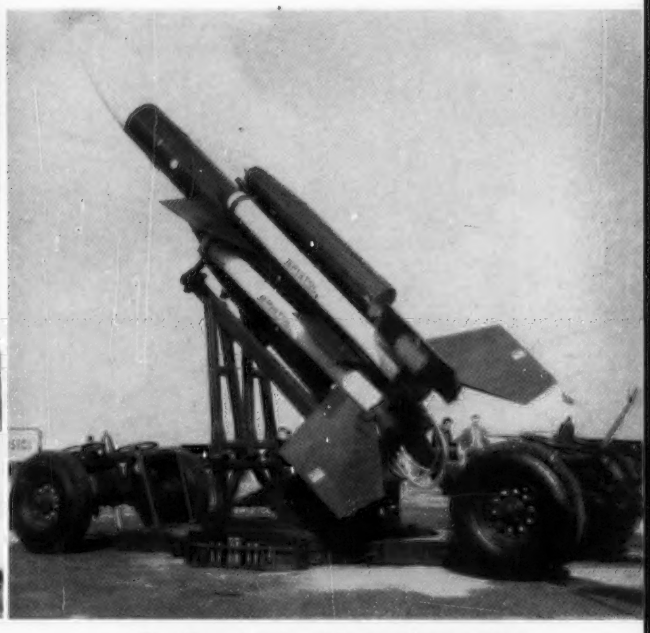
Bristol / Ferranti Bloodhound

rocket swing-away unique as ramjet takes hold



Aft hinge attachment of self-detachable rockets and large rocket vanes is shown in this rear view. Smaller airfoil near the top of picture is a double-wedge wing which pivots at its mid-point in changing the missiles flight path.



Bloodhound and mobile launching system. Missile is powered by two ramjets which are accelerated to operating speed by four rocket boosters shown in white. Missile is also fired from fixed sites.

Bloodhound, the first ground-to-air guided weapon to go into service with Britain's active units is a result of intelligent planning, development, and production.

The Bristol/Ferranti team, inexperienced in the missiles field, overtook and outdistanced Britain's other aircraft firms in producing the weapon that is now that country's standard ground-to-air defense weapon.

How they did it:

- Centrally directed long range research and development
- Efficient design, planning and systems assessments
- Absence of inter-service rivalries

Bloodhound is powered by two Bristol-developed ramjets and four detachable rocket boosters. It is guided to the target by a self-contained radar homing system. It is not designed as a missile, but as a complete weapon system. It has its own target illuminating radar equipment, control posts, and launchers. All are coupled to form an automatic defense system which is self-contained except for the need to receive early warning information.

Solid propellant rocket boosters are used to get the missile off its launching platform and accelerated to speeds where compression of air flowing into the major powerplant can be achieved by ram. A unique booster attachment system then automatically releases the rockets' forward attachments. The rocket cases swing aft on a hinge joint and break away as the ramjets take over the propulsion task.

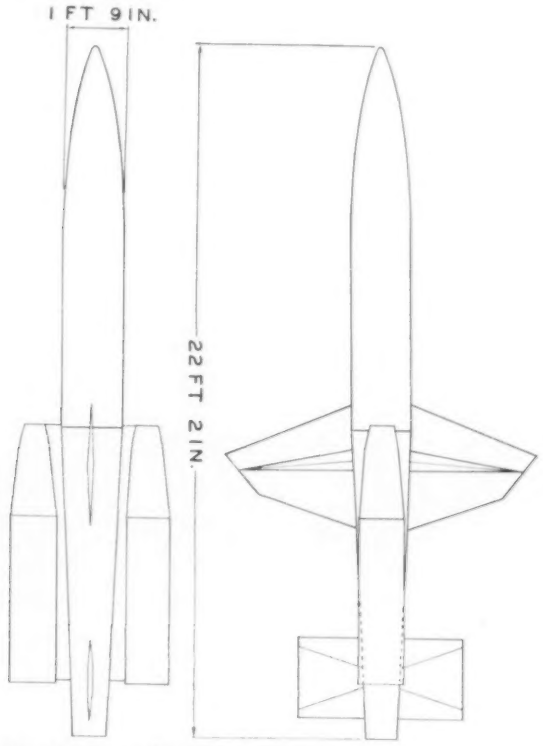
Interest in guided weapons at Bristol was initiated as a matter of private enterprise. This subsequently led to an official requirement to engage in the research which led to Bloodhound. Alliance with Ferranti Limited was suggested by the British Ministry of Supply, and has been outstandingly successful.

Continued on next page

Bloodhound

The Bristol group has overall responsibility for the enterprise, and has developed the weapon itself as well as the ramjet engines which propel it.

Ferranti has been responsible for the electronic equipment and the control and guidance system generally.



Bloodhound configuration and dimensions.

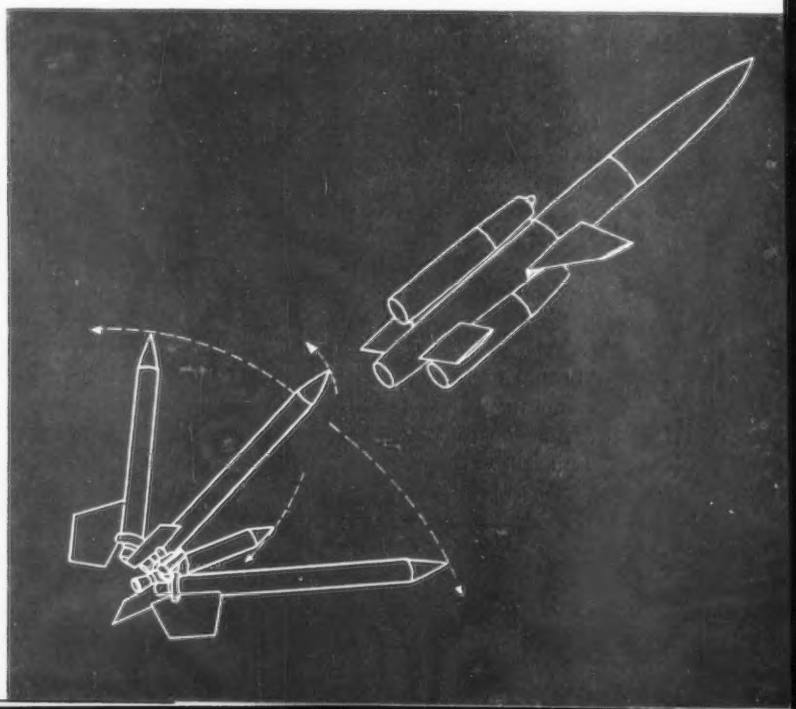
DESIGN CONSIDERATIONS:

Propulsion

For a ground-to-air anti-aircraft weapon, the basic requirements are a high initial acceleration, a speed considerably in excess of that to be expected of its quarry, and a fairly long range. According to the operational requirements of the weapon, one of three types of powerplant would be the more suitable: the turbojet, the ramjet, or the rocket motor.

Of these three the turbojet is the largest, the heaviest, and the most complicated. In addition, the speed required in a missile is at the top limit of the turbojet's capabilities. The rocket motor can provide ample performance, but is limited in range because of the large volume of propellant it requires (about six times as much as does a ramjet of equivalent performance). In general, rocket fuels also have the disadvantages of being expensive and needing special precautions for storage and handling.

Compared with the turbojet, the ramjet is small, light, and easily maintained. It uses kerosene type fuel which is safer and easier to handle, and its fuel consumption is moderate enough to permit long range interceptions. It can provide the speed necessary to counter piloted aircraft, but owing to its dependence on ram for the compression of the air it inhales, it cannot operate at low speeds. Ramjet powered vehicles therefore, must obtain initial acceleration by some other means. This is very easily achieved using rocket



BOOSTER SEPARATION

Missile, under ram jet power, is shown "flying away" from expended booster rockets. When the missile is accelerated to the speed at which the ramjets begin operating, the forward attachment points of the booster rockets are automatically disengaged. The rockets then swing out on their aft hinge joints, and open an expandable ring clamp which had secured them to the missile. As the ring clamp opens, the missile literally "flies away" from the detached rockets and control vanes.

booster motors which can be jettisoned when they have served their purpose.

Thus the ramjet was chosen as a power unit for the new weapon. About five years after the war, work on ramjets began at Bristol Aero-Engines with a contract from the Ministry of Supply to develop the Twin Ramjet Test Vehicle. With the help of the Royal Aircraft Establishment which had proposed the design of the vehicle, and on the foundation of experience derived from a collaborative agreement with the Boeing Airplane Co., Bristol put in hand an intensive program of research and flight trials.

Guidance

The second group of problems, those concerning control and guidance, have been handled by Ferranti.

There are three basic forms of missile guidance: command, beam-riding, and homing. Command guidance is simply the remote control of the missile by an operator or a computer. Though simple, control is not necessarily accurate. With this system the quantity of radar equipment required to handle a given number of missiles is inconveniently large.

In the beam-riding system, the missile follows a beam so directed as to give the missile a flight path intersecting that of the target.

Homing guidance differs from the two previous methods in that all the computation is done in the missile. There are in fact, three forms of homing: passive, active, and semi-active.

In passive homing the missile follows a radiation given off by the target as an unavoidable by-product of its operation. Homing on infrared radiation is an example of this method.

In active homing the missile itself projects radiations and is guided by their reflection from the target.

Between these two extremes is the semi-active system in which radiation is projected toward the target by a "third party" source and the missile is guided by the reflection of the beam from the target. This system is analogous to seeing an aircraft illuminated by a searchlight. The "third party" source is often described as target-illuminating radar. Any number of missiles can be directed by a single target illuminating source. This simplifies the ground installation and confers great flexibility of rate of fire.

Many difficulties attend the design of control and guidance equipment to be carried in the missile. It must withstand the high acceleration of the launch and the violent vibrations which may occur in flight. Among the rigorous tests applied to the radar equipment for Bloodhound is one in which it is allowed to fall free from a height such that it is subjected to a force twice as great as the acceleration force encountered during the boost powered phase of flight.

Sleek nose cone and short pivoting wings are seen on this Bloodhound mounted on a mobile field launcher.

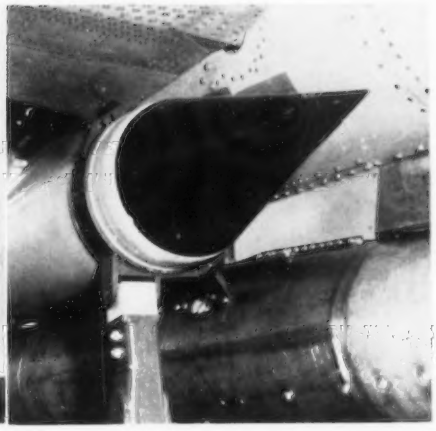
The guidance equipment must also be unaffected by violent maneuvers. During development trials it was found that aeroelastic flexing of the body of the vehicle could interact with the control response in such a way as to be amplified until the whole vehicle was destroyed. Similar effects on a much smaller scale can cause serious inaccuracy in flight control.

All these effects have been taken very seriously into account in planning the configuration of Bloodhound, and as a consequence it is matched to the homing guidance system. Bloodhound missiles have been flown faster and farther than any other British interceptor missile. They hit the desired target.

Continued on next page

Close up of rear attachment points for booster. Note accessibility of launching lines, hydraulic, and air connections.

Ramjets (false inlet cover) are mounted top and bottom of Bloodhound. Forward resting cradle for booster rocket (detached here) is shown at lower left.



As missile is fired, the support arm swings forward, releasing the horizontal locating pin. Pivot of double wedge wing is seen top center.

It is important to remember that Bloodhound is not simply a missile; it is a complete weapon system. It includes target-illuminating radar equipment, control posts, and launchers for the missiles themselves. These elements together form a complete and largely automatic defense system which is self-contained except for the need to receive early warning.

As soon as the target comes within range the missiles are ready for firing. Almost all the preliminary operations including the checking of missile serviceability are automatic, but the firing sequence can be broken off at any time before actual launch and restarted after any required interval.

To achieve flexibility in operation the elements of the Bloodhound system have been made readily transportable. The radar and control equipment can be housed in mobile vans. The launchers are easily transportable and can be dismantled or installed relatively quickly. Adjustments to meet a changing tactical situation can thus be made rapidly and at short notice. Alternatively, the system is equally suitable for permanent installation on a prepared site.

ABOUT THE RAMJET

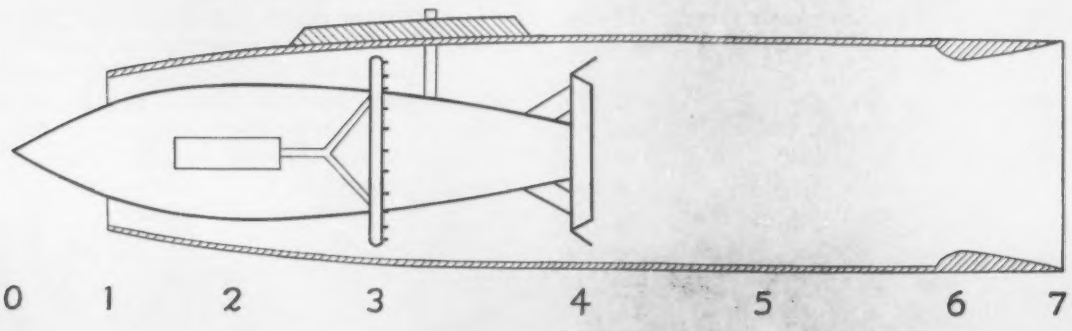
The most striking thing about the ramjet is its simplicity. The basic engine configuration is completely devoid of moving parts.

Because the ramjet has no mechanical compression, it must depend entirely upon ram effect of its forward speed to supply air to the combustion chamber. Precise inlet design is a must to provide an opening that will allow the correct amount of air to reach the combustion chamber. Accurate fuel control must be maintained.

Compression obtained at various speeds may be stated roughly.

Mach Number	Ram Pressure Ratio
0	1.00
1	1.89
2	7.83
3	37.00
4	157.00

0 FREE AIR STREAM
1 AIR INLET
2 FUEL CONTROL
3 FUEL INJECTION RING
4 FLAME HOLDER
5 COMBUSTION CHAMBER
6 NOZZLE THROAT
7 NOZZLE EXIT



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production concepts of the CF-105 Arrow

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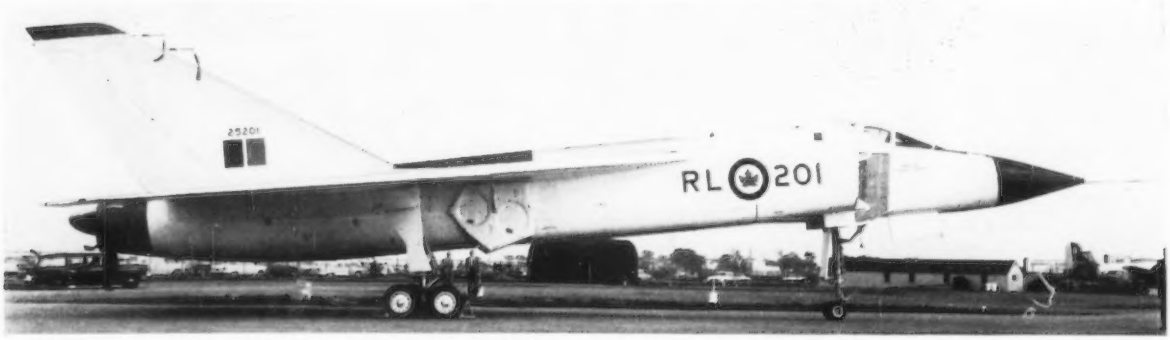
by: **James J. Keegan and T. R. Darmody**, Vice-Presidents, M & T Co.
S. Peter Kaprielyan, Technical Editor

THE MEN:

Four men who coordinated the efforts of all phases of engineering which went into creating the Arrow. From left: R. N. Lindley, Chief Engineer; J. C. Floyd, vice president engineering; Guest Hake, project designer; and J. Chamberlin, chief of technical design.

Production planning team. Standing, from left: Harvey R. Smith, vice-president, manufacturing; F. C. Richardson, plant engineer; C. N. Lucas, procurement manager; W. H. Riggs, production shop manager; H. F. Young, production engineering manager. Seated, left, Norman Parsons, production control manager; and S. L. Wilson, industrial engineering manager.

THE PRODUCT:



The distinctive features of the dartlike Arrow are its long, mildly area-ruled fuselage with relatively straight sides; two, large almost rectangular air inlets, with wedge-shaped deflectors, astride the cockpit; short 60 deg delta wings with elevons in trailing edge; and a high, rakish central fin. It is equipped with one of the most advanced integrated electronic systems to assist the crew in operation, navigation, and fire control. Some 11 miles of wiring and about 3000 vacuum tubes go into the system. At maximum speed the power output of the Arrow is about 60,000 lb thrust. Fuel consumption at supersonic speeds is roughly 500 lb per min. The air conditioning equipment required to keep the Arrow cool in supersonic flight is sufficient to produce 23 tons of ice a day.

The first problem faced by management was that of organizing engineering effort to integrate, on an exchange basis, the most advanced design, production, and testing concepts from Canada, Britain, and the United States. Limitations of wind tunnel facilities in Canada necessitated the use of U. S. facilities; also, induced engineers to explore additional means of obtaining aerodynamic data. The facilities of the National Aeronautical Establishment in Ottawa were used, as well as those of the Cornell Aeronautical Lab in Buffalo, and the NACA Lewis Lab in Cleveland. A total of 17 models, ranging in scale from one-eightieth to one-sixth were tested under simulated flight conditions up to March 2. Eleven free-flight models were fired between December 1954 and January 1957: two at the NACA range in Virginia and nine at the CARDE range at Point Petre, Ontario. The freeflight models, instrumented to transmit performance data, were mounted on the nose of booster rockets. All launchings and booster separations were effected successfully.

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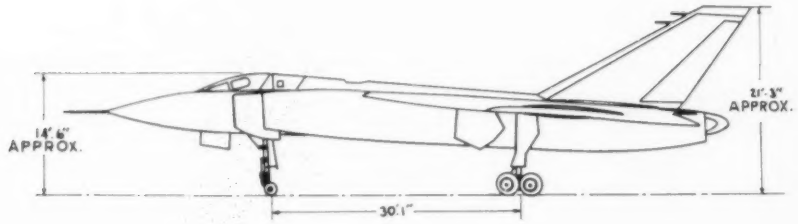
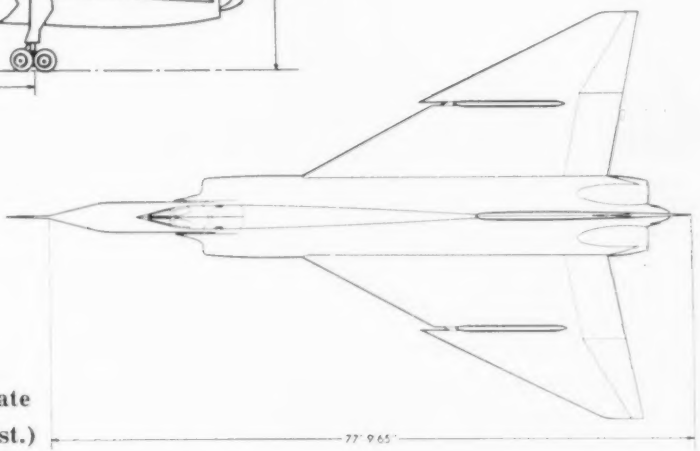




Vital Statistics of the ARROW

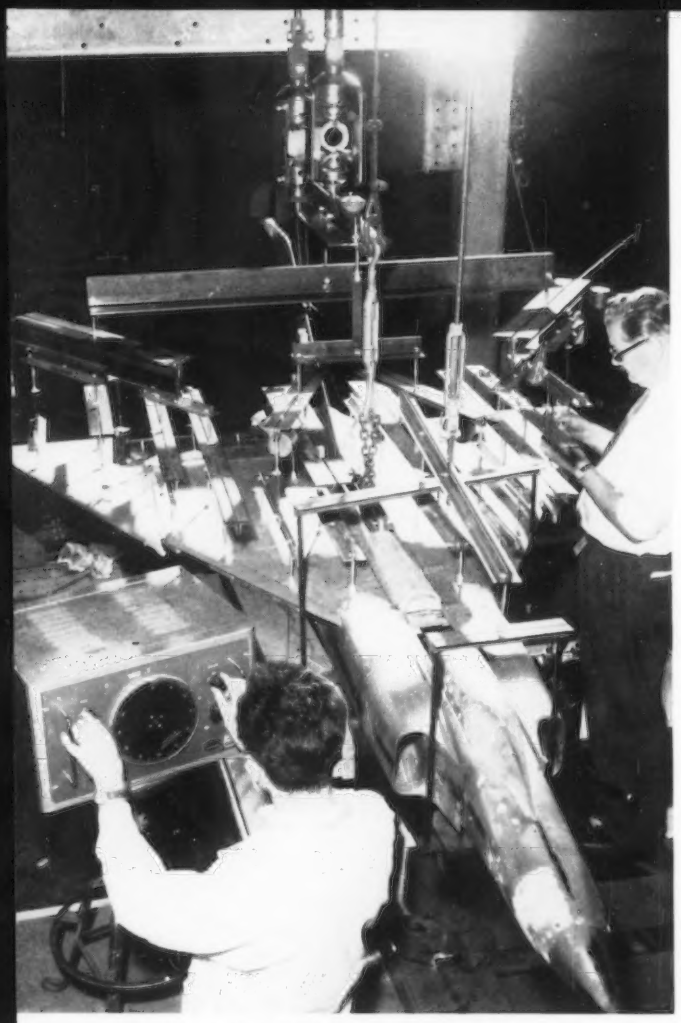
Gross Weight	60,000 lb +
Crew	Two, in tandem
Armament	Missiles or Alternate
Speed	1200-1600 mph (est.)
Range	1000 miles (est.)
Max Time Aloft	40 minutes (est.)
Operational Ceiling	75,000 ft (est.)
Basic Mission	Long Range Interception
Total Max Thrust (with afterburning)	60,000 lb
Max Take-off Weight	60,000 lb
Power Plant	
Initial	2 Pratt & Whitney J75 Turbines
Eventual	2 Orenda Iroquois PS-13 Turbines

CF-105 Arrow

The second problem consisted of exerting maximum engineering and production effort, toward the Arrow, without hampering the concurrent CF-100 production. This problem was attacked from several directions simultaneously, as follows:

- Extensive use of mockups and models
- Adoption of glass cloth process
- Incorporation of producibility features
- Procurement of consultant and subcontractor services
- Adoption of advanced manufacturing techniques
- Procurement of new equipment

The third problem consisted of operational difficulties arising from floor space limitations. To relieve this, as design and production engineering work neared completion, 176,000 sq ft of floor space was created, expanding the total manufacturing area to 1½ million sq ft.

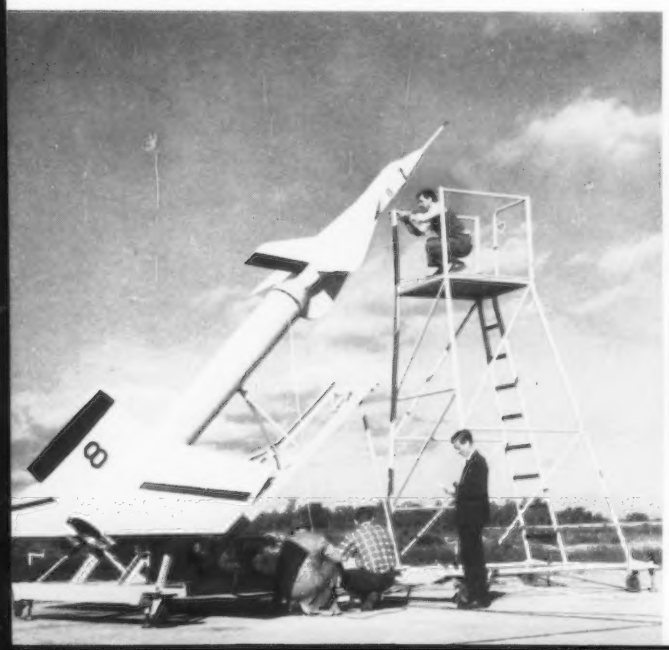


Checking of free-flight model during manufacture.

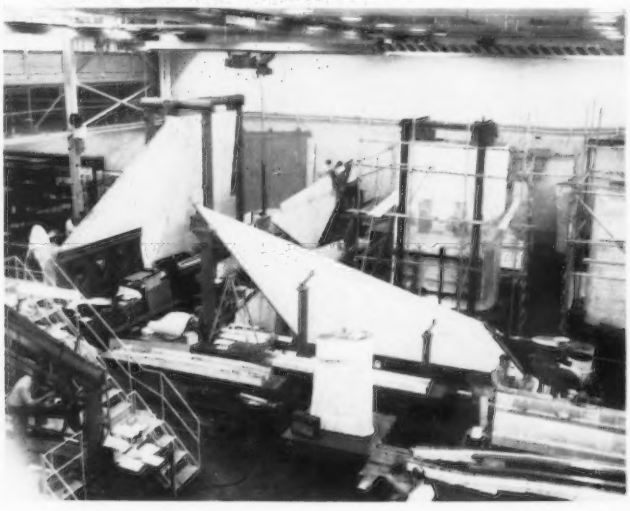
Extensive Use of Mockups and Models

The preliminary design of the Arrow was completed in 1954 but revisions were needed to cope with the changing engine availability schedules. To investigate resulting accessibility and clearance problems, detail mockups were built of the ship and the engines. The detachable armament pack, which gives the Arrow its versatility of purpose, was reproduced separately. In addition, a mobile cockpit mockup was built and

Free-flight model being readied for launching.



View of full-scale master models.



installed on a truck in taxing attitude, to resolve all visibility problems. Accurate, reduced scale plastic models were used to simulate flight loads and to determine optimum structural requirements.

Adoption of Glass Cloth Process

Avro's early adoption of this exacting process, to record engineering design, contributed to the acceleration of manufacturing by eliminating the repetitive layouts required for production. The M & T Co. was retained for its extensive experience in this engineering procedure.

Incorporation of Producibility Features

Great effort was spent for the incorporation of design producibility features right from inception and in the establishment of a qualification program to render the first Arrow a production item, rather than a prototype. Accurate full-scale models and mockups were used to preclude unforeseen manufacturing difficulties. To manufacture the approximately 38,000 detailed parts of this aircraft about 72,000 detailed tools were used in addition to the large jigs and fixtures. This indicates a ratio of about 1.9 tools per part.

Procurement of Subcontractor Services

Over 11,000 items of equipment were required for the Arrow. A substantial number of these were procured from over 650 outside sources, Canadian when possible. Frequent adaptations of equipment were necessary to meet the stringent tolerance specifications. The development of a special 4000 psi hydraulic system is a good example of the teamwork between suppliers of equipment, high-strength steel tubing manufacturers, and AVRO engineers. The nature of the ship made unusual requirements the rule rather than the exception.

The extensive use of titanium, Inconel, magnesium, high tensile aluminum, and stainless steel presented diverse manufacturing and inspection problems. In one instance, special heat treating facilities were established to process a large landing gear forging.

Adoption of Advanced Manufacturing Techniques

To reduce assembly procedure to a minimum, metal-to-metal bonding and sculpture milling were used. While bonding of aluminum presented no special difficulties, considerable experimentation was needed to perfect magnesium bonding through the use of an autoclave. To form contoured panels of magnesium, sheets were secured on heavy aluminum templates, wrapped in felt, and enclosed in polyvinyl alcohol bags. These were then evacuated and cured in the autoclave, assuming the required contours. The same procedure was also used to bond composite assemblies. Another novel method was the testing of integral fuel tank joints for leakage by introducing refrigerant gas (Freon) and using a "snifter" detector.

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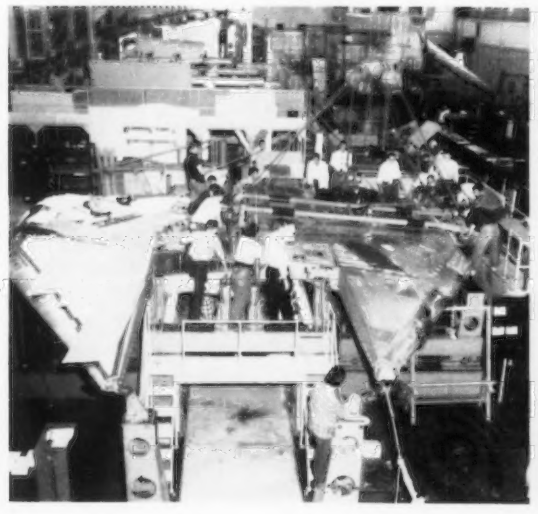
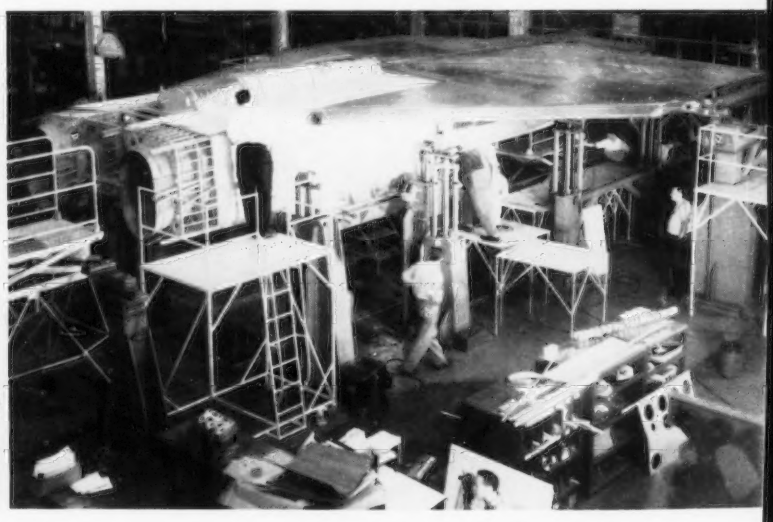
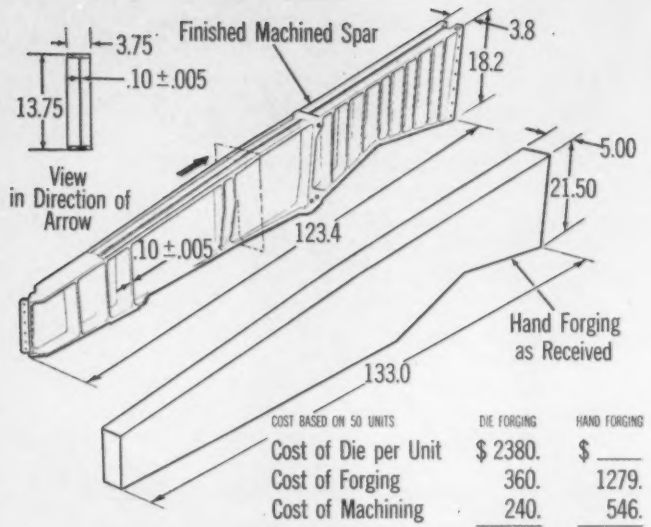
Final assembly of inner wing.



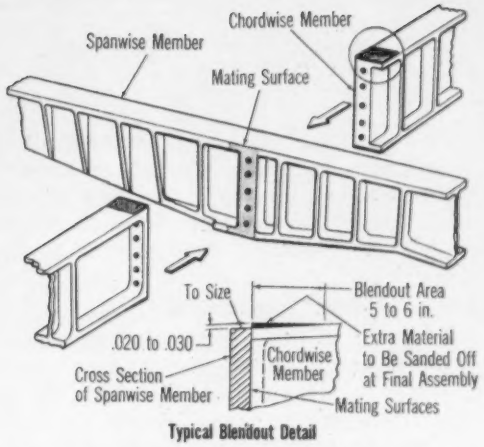
Assembly of fuselage center section and inner wing.





COST BASED ON 50 UNITS	DIE FORGING	HAND FORGING
Cost of Die per Unit	$ 2380.	$ ____
Cost of Forging	360.	1279.
Cost of Machining	240.	546.
Total Cost	$ 2980.	$ 1825.

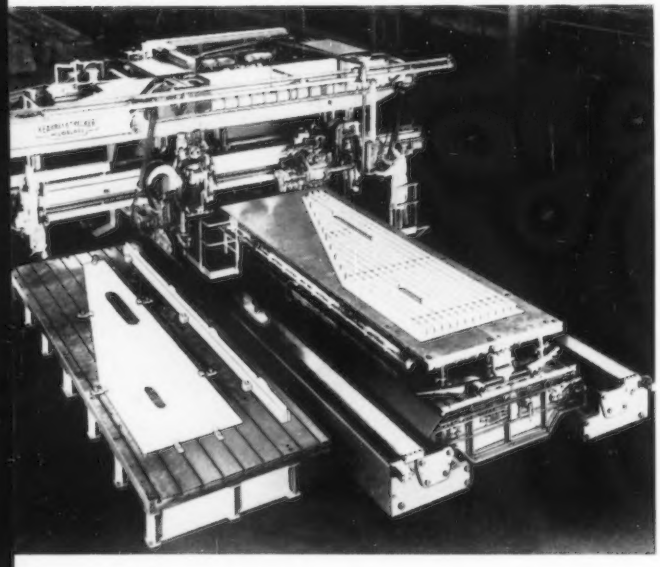
Cost comparison, based on 50 units, between spars made by die-forging and those machined from hand-forged slabs.



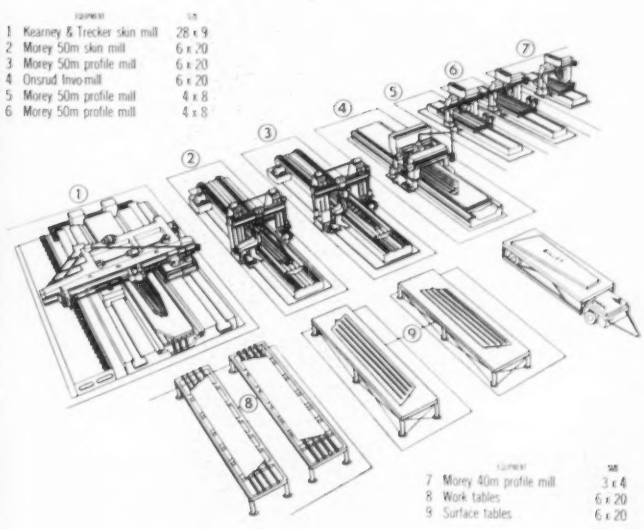
Typical Blendout Detail

Fuel-tight joints in integral wing tanks are prepared by blendout procedure as shown, to prevent mismatch. Sealant is later applied.

View of large skin milling machine showing template arrangement at left, and finished integrally-stiffened wing panel at right.



Machinery layout for skin milling.

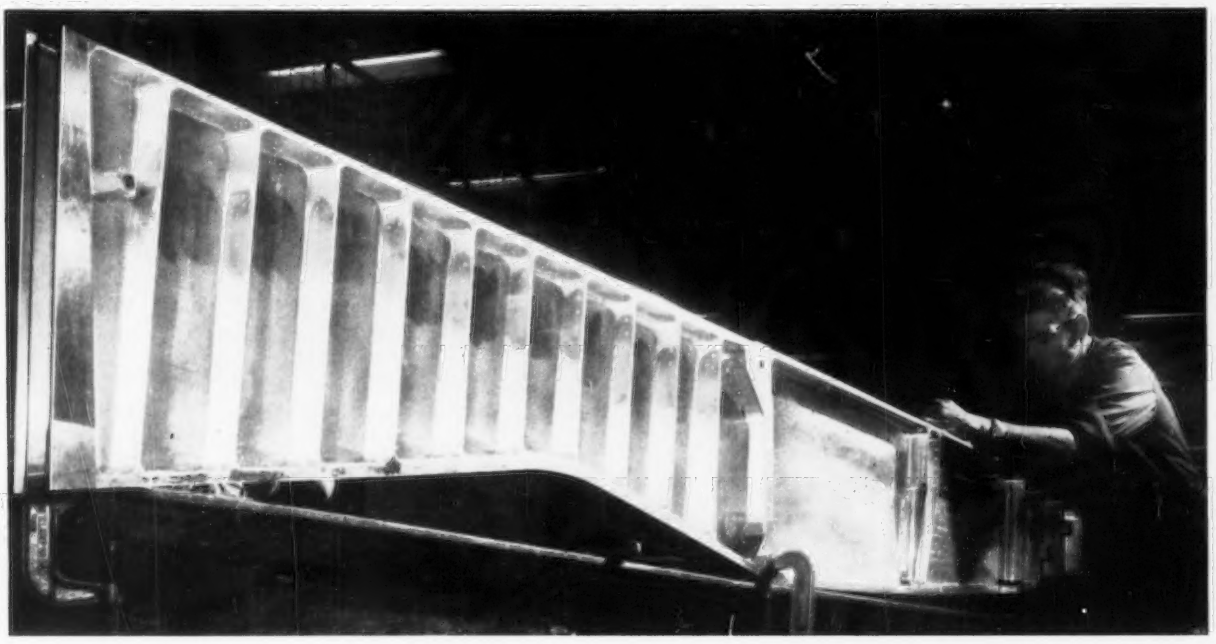


1	Kearney & Trecker skin mill	28 x 9
2	Morey 50m skin mill	6 x 20
3	Morey 50m profile mill	6 x 20
4	Onsrud Invo-mill	6 x 20
5	Morey 50m profile mill	4 x 8
6	Morey 50m profile mill	4 x 8
7	Morey 40m profile mill	3 x 4
8	Work tables	6 x 20
9	Surface tables	6 x 20

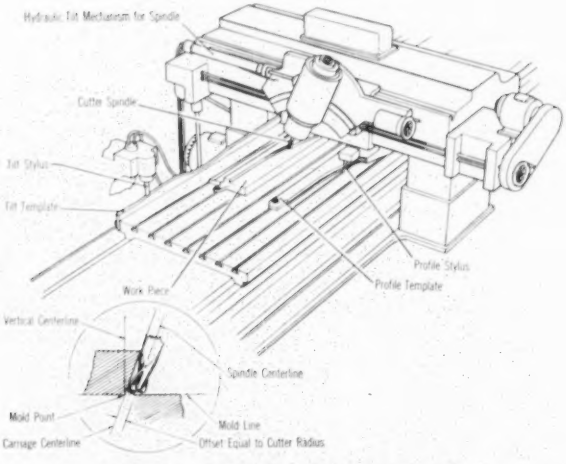
CF-105 Arrow

Procurement of New Equipment

An IBM 704 data processing machine, Avro's being the only one outside the U. S., was installed to save man-hours in the solution of aerodynamic and stress problems. To enable the forming of heavy gage material a 15,000 ton hydraulic, rubber pad forming press was procured from the Siempelkamp Co., of Germany. Unusual feature of this press is that pressure is exerted from below, forcing the load table up into the rubber pad. Also, a number of tracer-controlled, skin milling machines were purchased for specific applications. A Kearney & Trecker skin milling machine was equipped with automatic tracer-control for both horizontal plane and rise-and-fall vertical plane movements. It has a working surface table 9 by 28 ft. This machine, provided with a universal vacuum chuck which can be tilted in two directions and be ro-



Wing auxiliary spar is machined from hand forging.



Setup for milling variable flange angles.

tated, was utilized in milling integrally stiffened panels with compound tapers and converging stringers. The tracer unit of this machine is located on an extension of the travelling beam, and follows the contour template mounted on an adjacent table. An indexing mechanism guides the horizontal cutter across the beam. At the same time the stylus is indexed over the template table in a direct ratio. Thus, at the completion of one cut, both cutter and stylus are indexed across the machine in readiness for the next cut. Two spindle heads are carried on the beam for horizontal milling. The vertical head has provision for tilting the spindle in two directions. To minimize end milling difficulties, mismatch for cutter blendout was provided; also, generous blend radii were allowed to enable use of sturdy cutters. Horizontal milling heads were used for the greater portion of metal removal. Employing rise-and-fall trace for thickness variation, with a width and depth of cut $2\frac{1}{2}$ and $1\frac{1}{2}$ in. respectively, a speed of 3600 rpm, and a feed of 100 ipm; metal removal rates of 375 cu in. per min were attained.

A Morey profile miller was utilized to supplement the larger miller. Provided with similar controlling devices, this machine is a planer arrangement with a moving table. The vertical spindle head traverses across the beam and can be raised and lowered relative to the work table. For horizontal milling cuts, an attachment is mounted on the spindle nose. Three positions are provided on the spindle head for attachment of the horizontal plane hydraulic tracer unit, allowing utilization of complete work table area. For rise-and-fall milling, a separate tracer is used mounted on a fixed column off the machine bed. No direct mechanical tie-in with the spindle exists; vertical movement during rise and fall cuts is effected through an electro-hydraulic system from the tracer. In this case,

CF-105 Arrow

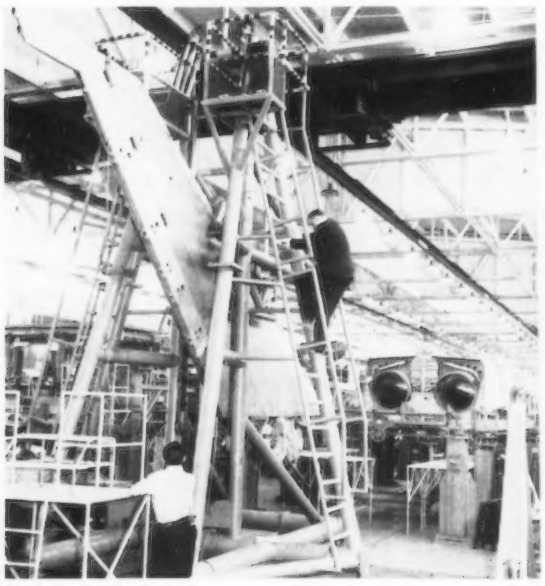
Test rig control panel simulates complete aircraft electrical system.

the master template and the work are located on the same table.

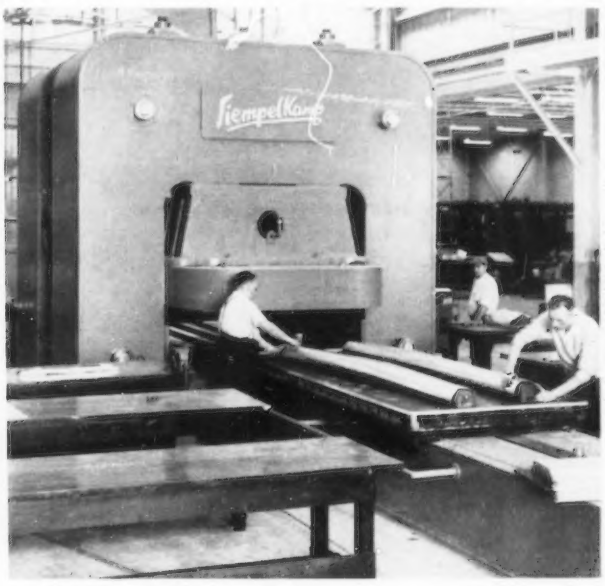
An Onsrud Invo-mill as another supplement to the skin miller, is used for end milling and routing. Templates are mounted directly above the work, as in sheet routing practice. Without tilting features, and less automated than skin millers, this unit is used for finishing confined pockets and peripheries at right angles to the plane of the work table. The travelling table here can accommodate skins up to 20 by 6 ft. The cutting spindle is suspended between two beams, and can be rotated in its mounting; it is also provided with a pneumatic compensator to assist the operator in maintaining contact with the template. The operator, riding the gantry controls the directional movement of the template follower through a "joystick."

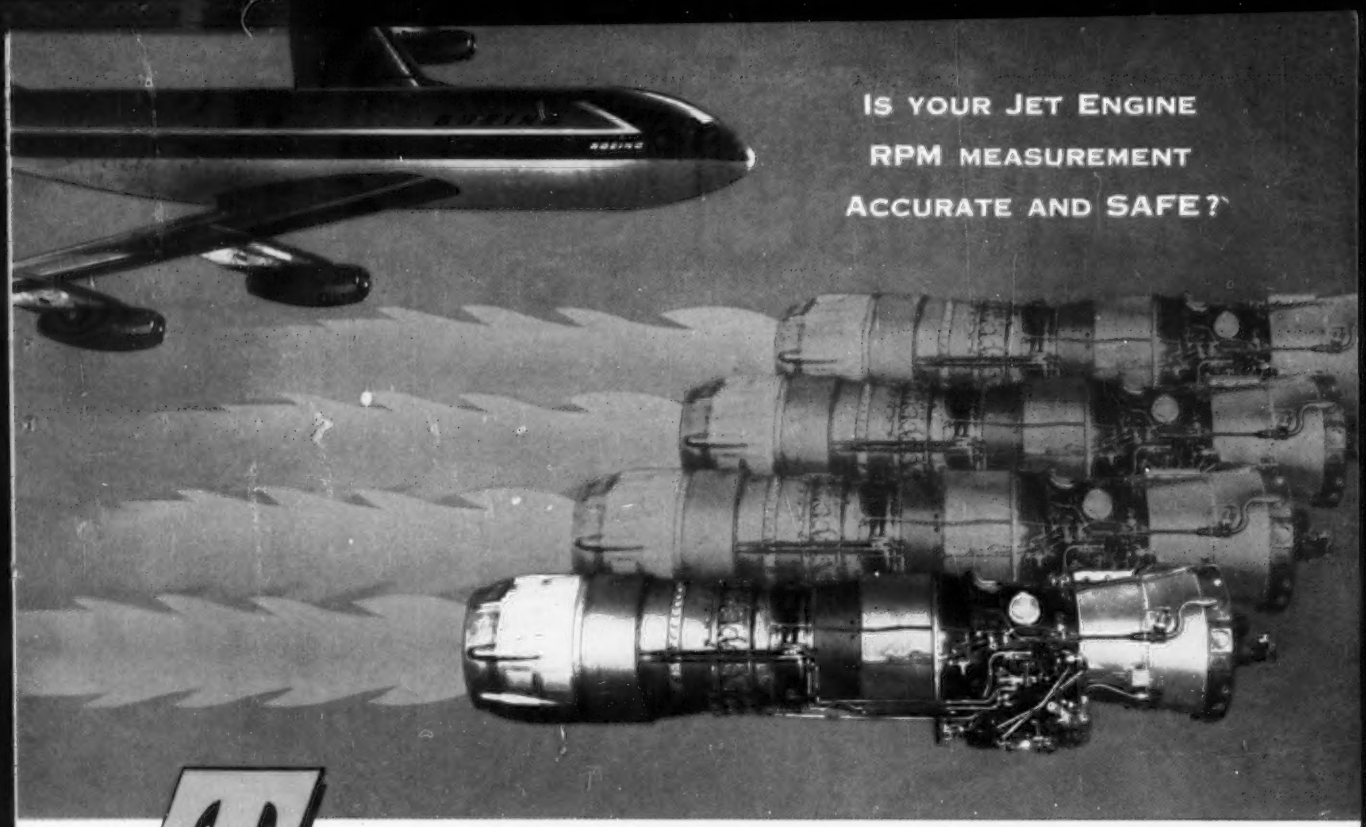
Additional profile millers, provided with automatic tilting heads, are used to simplify template manufacture. Here, tilt angle is controlled by a template mounted on the side of the table where linear rise and fall on the template is converted into an angular movement at the cutting head. Automatic tilting heads are used to generate bevel angles of airfoil-contoured flanges. For 360 deg horizontal plane profiling, except in skin milling, hand control of feed rate was found advantageous. This allowed rounding of corners at lower speeds and the straight or shallow cutting at higher rates.

Vertical fin in marry-up assembly trolley.



15,000-ton hydraulic rubber pad forming press is used for Arrow sheet metal parts.





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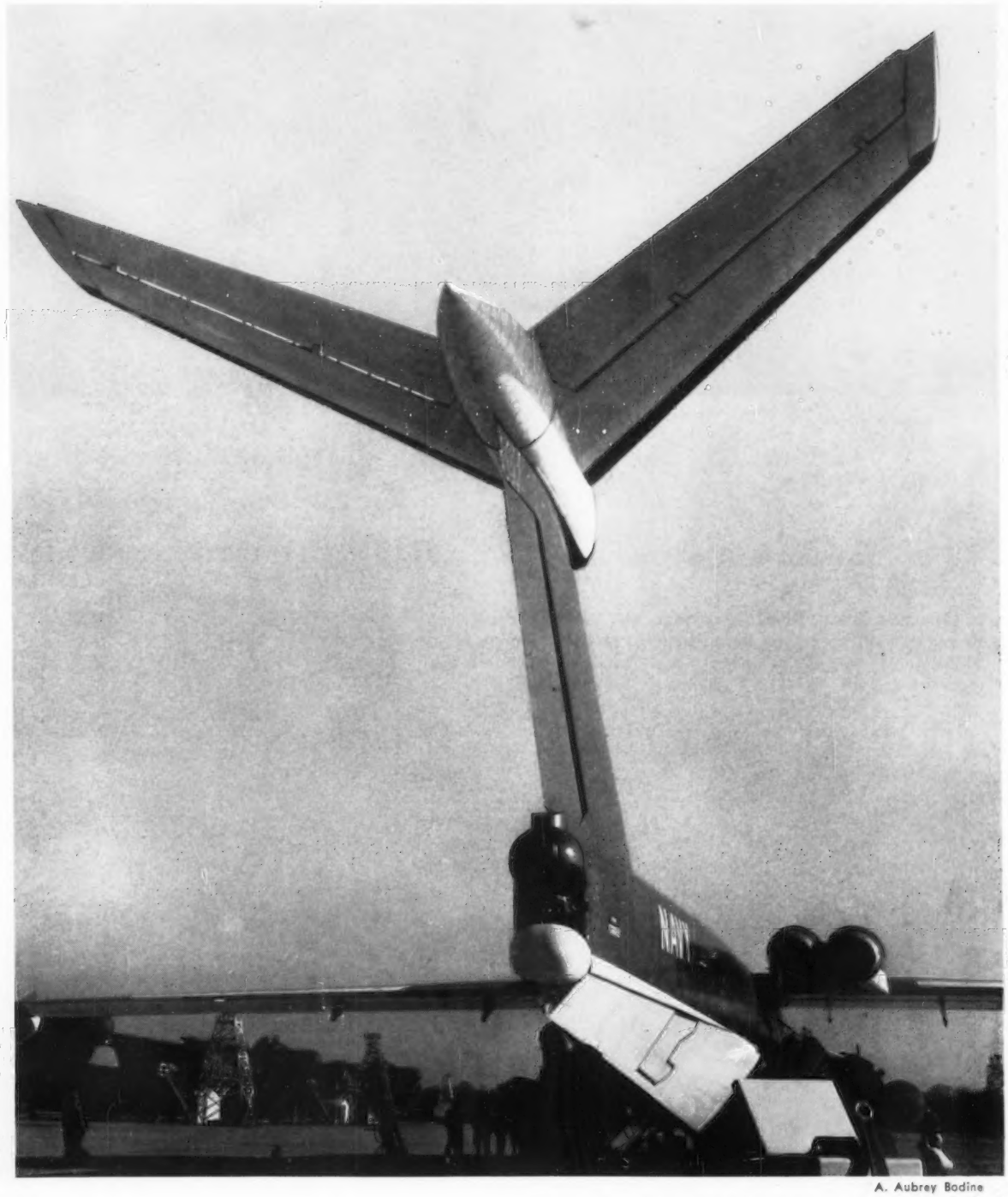
SeaMaster



A. Aubrey Bodine

first production models have revamped tail, new engines, unique wing design

by John Kushnerick, Materials Editor

Eighteen production models of the up again, down again, P6M SeaMaster are at various stages of completion at the Martin Company's Baltimore plant. The "world's first multi-jet seaplane," plagued by "flying tail troubles" in early tests, received renewed attention from naval aviation officials after successful flights this month with a redesigned elevator control system.

Designed for volume producibility from its inception, few costly changes have been incorporated into the original experimental P6M configuration or existing plant facilities to build production ships.

Six "Y" models now being built will retain the four afterburner equipped Allison J-71 turbojets as the power plant; but production versions will have four PW J-75s mounted in the twin nacelles high atop the swept-back, negative dihedral wings. Thus, with about 60,000 pounds of thrust, slightly in excess of design requirements, Martin and the Navy hope to push the mine laying, photo reconnaissance, attack flying boat to the heights of its original expectations.

Designed For Producibility

Martin's Design Producibility Unit played a major part in SeaMaster production. This group of engineering specialists provided design engineers with on-the-spot advice on feasibility techniques and insured that drawing tolerances were within practicable parameters.

The chief accomplishment of the producibility planning was to take advantage of the small hull cross-sectional area, and break down fabrication of the fuselage into units, as in most landplanes. Conventional seaplane construction procedure has been to assemble the fuselage in one piece, using large hull docks. Other producibility features were: the extensive use of extrusions in place of milled parts and extensive use of castings in the airframe structure. Martin's own foundry plays a considerable part in facilitating the delivery of castings on schedule.

Non-strategic plastic is used judiciously in wing floats, stabilizer, and interior components. Cast phenolic tooling is used in forming metal and plastic parts. Large airfoil sections, flooring, and bulkheads are fabricated of economical, adhesive bonded honeycomb sandwich.

Redesigned "flying tail" is the major change in production models of the P6M SeaMaster. Crashes of two experimental models were attributed to hydraulic tail malfunction.

Wing-To-Fuselage Tongue and Groove Splice

The SeaMaster wing hangs on a forged 7079-T6 aluminum alloy rib that starts out as the heaviest blocker type aluminum forging in the U. S. weighing about 3500 lb and measuring 11½ x 36 x 166 in. Machining and milling reduces the final rib weight to about 315 lb.

An unusual "tongue and groove" bolted wing skin joint serves as a wing attachment between wing and fuselage.

A flange on the large forging and a strap bolted over the wing skin forms the female side of the tongue and groove fitting. This is mated with the thick wing-skin stubs on the hull forming the male side of the fitting.

After the hull and the wing are complete, both the tongue and the groove are machined with a special portable miller. A roller mounted on the shaft of the miller follows a precision contoured tracker cam.

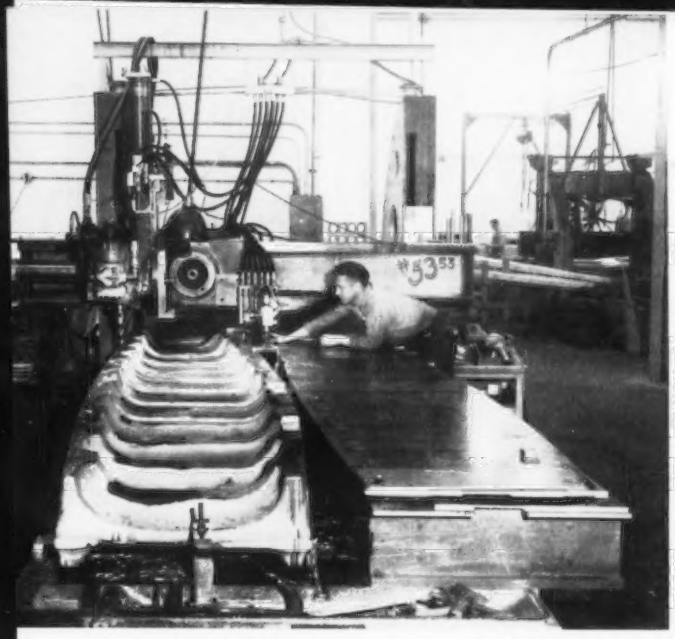
The tongue, on the hull, is machined to .750 in. thickness, and the groove is finished to a .786 in. gap.

After machining, alignment jigs are used to drill seventy-four ⅝ in. holes in the upper splice, and seventy-one in the lower splice. Holes are reamed to .625 in., and attachment is effected with AMS 4925 titanium bolts having a minimum shear strength of 75,000 psi.

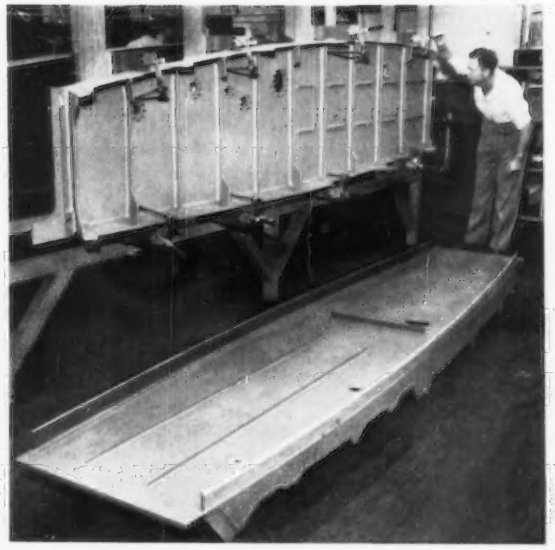
Automatic Slug Riveting For Wing Sections

Sections of the large swept-back negative dihedral wing are utilized as fuel tanks without benefit of liners or secondary cells. Fuel integrity is insured in riveted areas by highly controlled automatic installation of refrigerated slug rivets. EC 801 sealant originally applied as a double thick fillet at the attachment points has been eliminated since automatically installed rivets have satisfied all leak test requirements.

The Drivmatic riveting machine is used on the 10 x 37 foot wing panel. It is tape controlled through coded holes punched in seven different channels of a standard 35 mm film. The machine clamps the part to be worked in position, drills



The rib of the center wing section on SeaMaster is machined from this huge forging which weighs 3500 lbs. as forged. The finished machined rib weighs only 315 lb.



Forging of 7079-T6 aluminum alloy is main structural member between hull wing stub and wing, rib on holding fixture is outboard side; rib on floor inboard side.

SPECIFICATIONS

Mission	Attack	Length	134 ft	Payload	30,000 lb	Span	100 ft
Cruise alt.	40,000 ft	Height	31 ft	Gross wt.	160,000 lb	Wing area	1900 sq ft
Speed	Over 600 mph	Hull width	10 ft	Crew	Four	Vert. tail area	213 sq ft

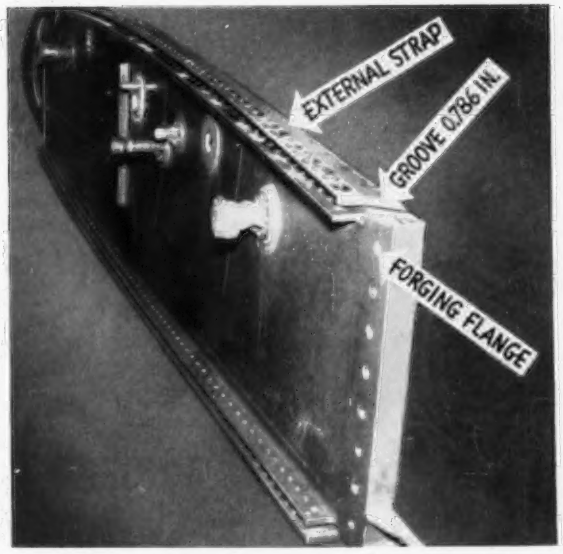
SeaMaster

and countersinks the rivet hole, injects the refrigerated slug rivet, squeezes and vibrates the rivet, mills the top head flush with the wing, unclamps the part, and resets itself for the next cycle.

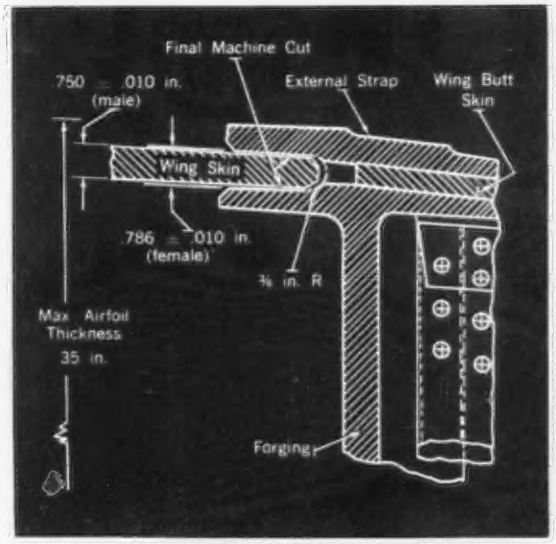
The rivets are headless slugs of 2024 aluminum which have been cut to length with ends squared and chamfered. Rivets are heat treated then stored at −30° F in a special refrigerator attached to the machine. The slugs are fed directly from the refrigerator through an insulated chute to the riveter. Feed chutes are internally coated with Teflon to minimize friction and to prevent condensation.

Titanium

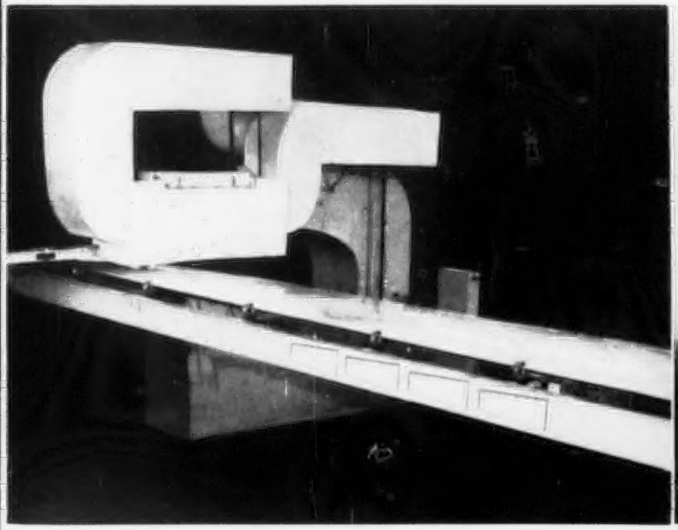
About 500 titanium components are used in the SeaMaster, the largest being a formed sheet bulkhead with an area of about 1350 sq in. Martin claims to have investigated forming and welding of titanium before some of the techniques, now generally accepted, were known. Commer-



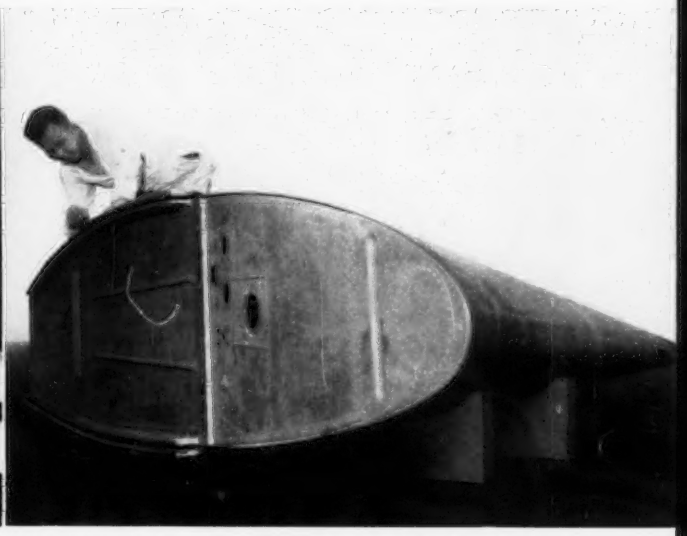
Machined and drilled rib of center wing section. Groove for the tongue and groove jointures with the wing stub is formed by the forged rib flange and an external strap.



Cross section of tongue and groove wing splice between wing butt and right wing. Maximum airfoil thickness is 35 in. Machining tolerances are held to ±0.010 in.



Leak proof riveted joints are made, in the 40-ft center wing section, with this DrivMatic riveter. A refrigerator unit on top of machine stores and delivers rivets at —30° F.



Inboard end of center wing section with the forged aluminum alloy rib attached. Workman is shown inspecting the groove used to join the wing to the hull wing stub.

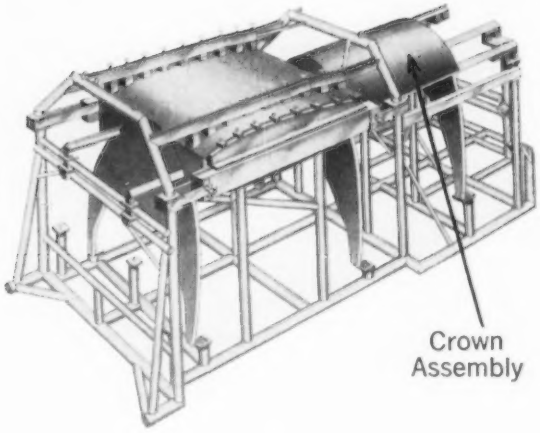
cially pure titanium is now welded in open air, using inert tungsten arc. Welding is performed automatically, and manually.

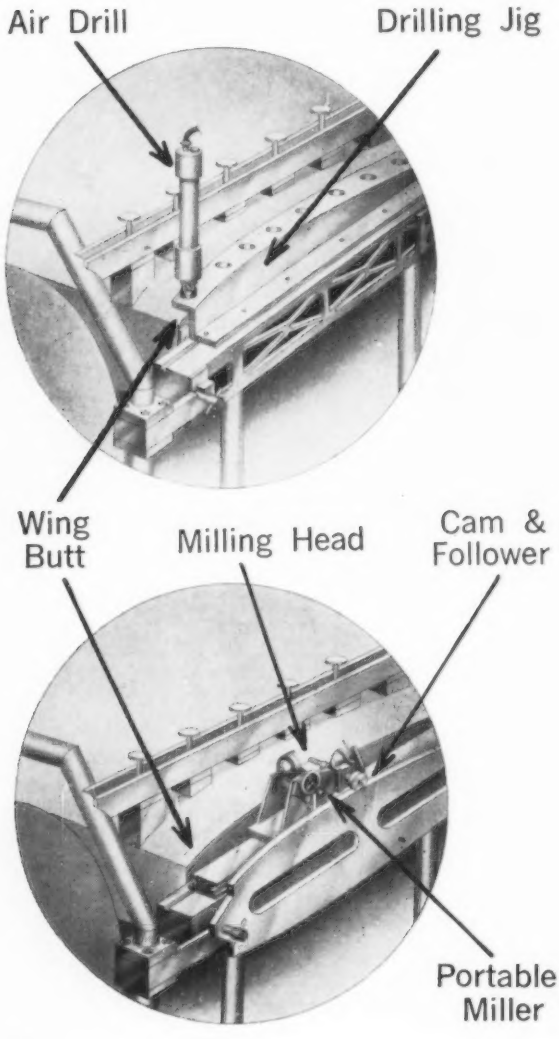
Titanium parts are first deburred with emery cloth, degreased in hot perchlorethylene vapor and cleaned in Alkon electro-cleaner without applying current. Cathodic cleaning methods are never used with titanium. In square butt joints, without filler rods, edges to be welded are jigged together tightly; with filler rod, a clearance of ½ to 1 wire thickness is used. Filler rods of commercially pure titanium with 55,000 psi yield strength are used with the unalloyed metal. Welding wire of A-110AT alloy is used on alloyed parts.

The weld joint is shielded on both sides to preclude embrittlement by atmospheric gases. Shielding is accomplished through a standard gas cup with a trailing edge shield, or a gas cup and trailing edge shield with inert gas back-up. Both argon and helium are used for inert atmosphere. Gas supply pressures are regulated to prevent an excessive rate of supply which creates a low pressure area in weldment section, tending to draw the outside atmosphere into the weld.

All welded parts are stress relieved. Un-

SeaMaster





Details of milling and drilling operations on tongue and groove wing splice.

alloyed titanium is stress relieved by heating to 950° F for 30 min. Weldments of A-110AT alloy, or weldments of pure and alloyed parts are stress relieved by heating to 1100° F for 30 min.

Satisfactory welds have a bright clean appearance. Gray coloration or light scale are indicative of contamination.

Anodizing Wing Skins

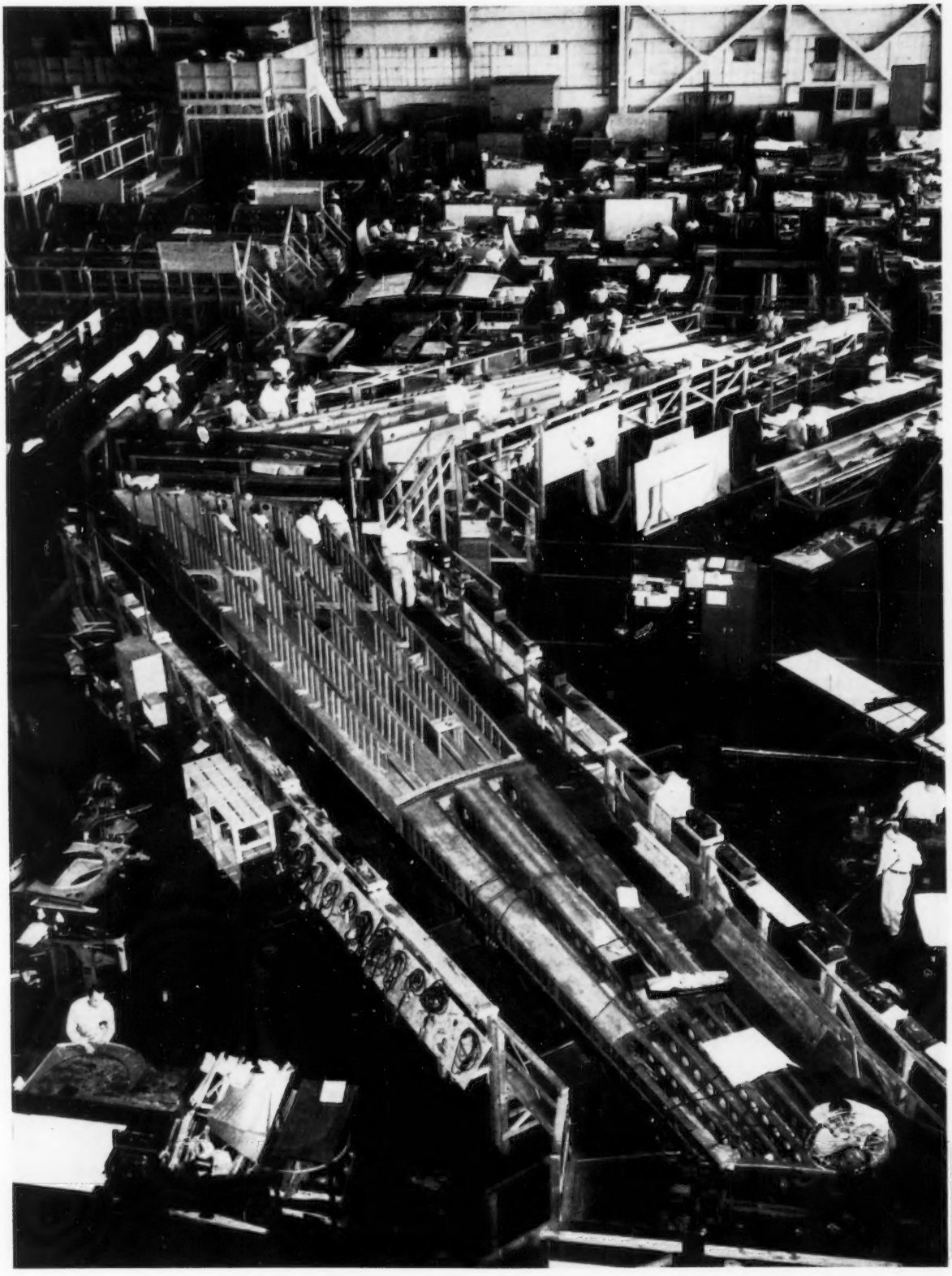
A protective anodic film is given all aluminum parts having an alloy content of 5 per cent copper or less, a total alloying content of 7.5 per cent copper or less, zinc and silicon.

Anodizing the large 40 foot aluminum wing skins is accomplished at a cost considerably below original expectations. Two 17,000 gallon steel tanks measuring 50 x 12 x 5 ft, were fabricated by expanding existing out-of-use tanks. The tanks were constructed on site and an enclosure built around them. The size of the tanks precluded installation in any existing building. The facility is a separate building complete with traveling crane, heating, and electrical equipment.

Electrical current requirements are larger than might be expected for the 40 foot skins since government specification require drilling and grooving to be completed prior to anodizing. This increases the surface area to be anodized by nearly 30 per cent. The tanks are equipped with automatic temperature controls and recorders, heating and cooling coils, compressed air agitation, and ventilating facilities.

The anodizing tank is charged with a solution of chromic acid containing 32 pounds of acid per 100 gal of water. Operating temperature is maintained between 90-95° F and the hydrogen ion concentration of the solution is held within a pH range of .4 to .7. Skins are immersed in the tank solution from a traveling crane. Electrical bases make the skin the anode and the steel tank the cathode. A current density of 1 ampere per square foot of surface is induced, increasing from 0-40 v over a five minute period. The skins are anodized at 40 v for about one hour, or sufficient time to deposit a coating of 200 mgm/sq ft. A rinse and sealing solution is provided in a second tank.

The rinse tank is maintained at 190° F and the hydrogen ion concentration is regulated a pH range of 4.0 and 6.0, by small additions of chromic acid. The skins are immersed in the air agitated rinse for 15 min, then dried by a warm air blast.



Wing sections are assembled in horizontal fixture which allows easy working access. Note heavy spanwise members and absence of formed ribs. Heavy wing skins add strength, maintain airfoil contour.

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numerically controlled rotary tables save time increase production at Lycoming

by **Otto Rasmussen**, Tool Engineer,
and **Vincent Beebe**, Supervisor of Machines,
Lycoming Div., Avco Manufacturing Corp.

tape operated rotary table positions complex jet engine milling operation automatically and precisely

The aircraft industry's growing trend toward numerically controlled equipment is in line with current producibility problems. Take for example the case of Lycoming Div., AVCO Manufacturing Corp., which recently installed a Pratt & Whitney numerically controlled, 42-in. rotary table, at its Stratford, Conn., plant.

Lycoming uses the table in conjunction with a Forge de Gilly horizontal mill. The head and cutting tools were specially designed for the job.

Repeat Accuracy

The elimination of repetitive set-up and error in calibration was the object. A jig boring or inspection set-up is greatly simplified by the use of a controlling tape. This is especially important in short runs since, once cut correctly, a tape may be stored and re-used to perform a required operation with repeat accuracy.

Workpiece Configuration

A typical operation at Lycoming is a subcontract jet engine case weldment for Ford.

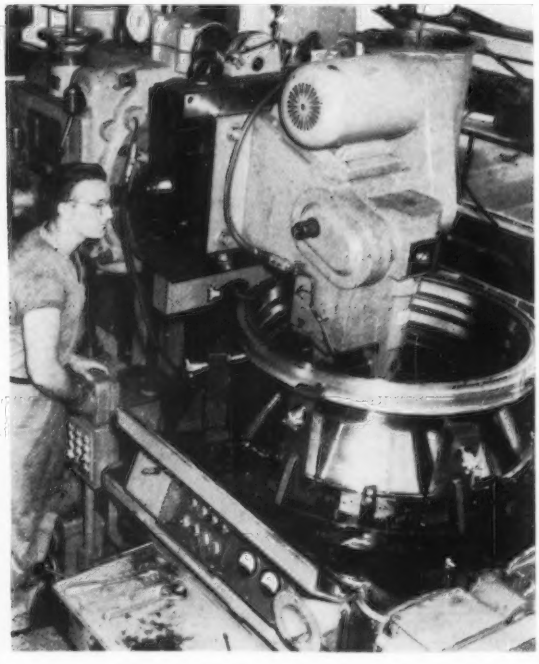
One operation calls for the milling of three rows of slots inside the case. The lower row has 70 slots, milled with a cutter 0.500 in. wide and 5.500 in. diam. The middle row has 88 slots; cutter width is 0.350 in. and diam 4.500 in. The upper row has 78 slots, using a cutter width of 0.450 in. and a diam of 4.450 in.

Slot spacing tolerance on a 31-in. diam is ± 45 seconds or ± 0.003 in.

This milling is one of the final machining

View of casing on rotary table revealing milled slots. Note sturdy clamp on case to damp vibration of cutting.

Overhead view of operations showing the control panel in foreground. Tape is located behind operator.



operations the case weldment will undergo. It requires great care to eliminate any possibility of error, hence scrappage.

To be used with the numerically controlled table, a horizontal boring mill was chosen, with a right angle milling head, built by the Producto Machine Co., Bridgeport, Conn.

Extra control switches in the tape reader provide two additional columns of 10 digits to control the boring mill saddle movement through interlocks, necessary for the three different heights and lengths of travel.

Tape Processing

A key feature of the Pratt & Whitney numerically controlled rotary table is the ease of tape punching.

A clerk, after only a nominal period of training, can punch out tapes for any of the above jobs. For the turbine weldment, for instance, the manufacturing engineering department writes the program charts to convert the specifications and positions from an angular dimension such as 20°, 30′, 40″, to a decimal reading of 20.5111. Using these program sheets the clerk manually punches the tape. For this particular job, with 236 individual blocks to be punched, the clerk

Operator checking depth of milled slots. The chips visible within casing are collected on a circular screen to facilitate removal.

spends six hours making more than 3000 holes necessary to do the work.

The control tape is then sent to the shop where it is inserted into the tape reader. The operator controls only the changing of cutters and the positioning of cutter heads to determine the depth and width of the slots as required. A limit switch with micrometer adjustment for depth control compensates for variation in cutter diameters.

Milling Operation

The boring mill function, of longitudinal saddle movement, is controlled by a hydraulic cylinder. The "in" and "out" moves are directed by the extra control switches.

To start the milling, the operator loads the case onto the fixture mounted on the rotary table; the workpiece is traversed under the cutting head; and the head is lowered to the first position.

When the machine is started, it positions itself radially, and advances longitudinally to start the cut. This cycle is repeated until the complete row of slots is milled. Then, the tape control comes to an automatic stop, the operator raises the head and changes the cutters for the next row of slots.

Numerical control causes the table to reach a position before the saddle can advance to make the cut. If the rotary table doesn't reach the prescribed position, the boring mill saddle will simply not advance.

Next, the head is lowered to the second level and the start cycle button is depressed. This advances the tape to the next block of information. The boring mill control panel is inter-locked with the tape reader to allow the operator to stop and start the cycle, at any time, for cutter change of depth check. In this instance, the speed and feed are 55 fpm and 1.5 ipm, removing 0.24 cu in. of stock per minute.

Cycle time for each slot is about 48 sec, which makes the total machining time for the weldment about five hours. To avoid trouble, the electrical and hydraulic equipment departments run periodic protective maintenance on the circuits and parts of this equipment.

Even though the tape material is strong enough to resist accidental tearing, a spare is always made as a precautionary measure. Estimated tape life is about 1000 hr.

About 30 pieces have been milled to date, all within the required radial tolerance.

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The prime purpose of this new monthly publication is to promote better communications between engineering and production personnel and between the manufacturers within the industry. In the past there has been no single publication serving as a common meeting ground and forum for the airing and solution of the combined complex problems of production and design. Original feature articles will deal with engineering and production by the most economically feasible methods. The approach will be one with emphasis on the whys and wherefores and on practical solutions to manufacturing problems.

New planes and missiles will be traced from design engineering, through the production line and all the way to inventory. Stress will be laid on how the design and the production engineers can and must work together to deliver the goods to the user—civilian or military.

AIRCRAFT AND MISSILES MANUFACTURING is needed

Research has proved the need for an entirely new kind of publication to fill a void that people in the industry feel strongly exists today. Independent studies by John T. Fosdick Associates, New York, conducted by personal interviews among key operating executives in manufacturing companies, indicate a "strong desire for concentrated information on new design and production techniques." These studies are being continued to keep a finger on the pulse of this fast-changing market.

A and MM controlled circulation

Through extensive field work, which is continuing, a list of more than 15,000 names has been built, one by one. Every name on the list represents someone whose function is related to manufacturing, engineering or purchasing. This includes design engineers (in manufacturing); production personnel, such as plant superintendents, tool engineers, and department heads; and purchasing executives. A and MM's bull's-eye circulation eliminates from your advertising expenditure the high cost of mass-circulation, general-appeal aviation magazines. You do not have to pay for reaching people connected with air carriers, maintenance operations, terminal airports and the like when your market is primarily the manufacturers of aircraft, missiles, engines and parts.

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Due to current trends in the industry, contracts are being awarded with far greater care as respects costs. As a result, the prime and subcontractors must learn to produce more economically and efficiently. They are eager for information on how to do their jobs better. They want to get it authoritatively and with the minimum of reading time—preferably between the covers of *one* magazine. This is the objective of AIRCRAFT AND MISSILES MANUFACTURING.

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machining honeycomb

plastic chucking material holds work for machining

expanded honeycomb accurately machined to ± .005 in. tolerance

gantry mills and band saws utilized

The growing use of structural bonded metal parts in highspeed aircraft and missiles is placing increasing emphasis on development of economical, reliable fabricating techniques. During the past decade, accent has been on the development of acceptable strength and reliability qualities in metal bonding—with fabrication costs a secondary consideration. In recent months this development has moved well into the mature volume-production stage through attainment of fully-acceptable and repeatable techniques, permitting serious attention to economies.

Accurate machining of the expanded honeycomb core to a ± .005-in. tolerance has proven to be an essential step in the fabrication of strong, reliable bonded metal parts.

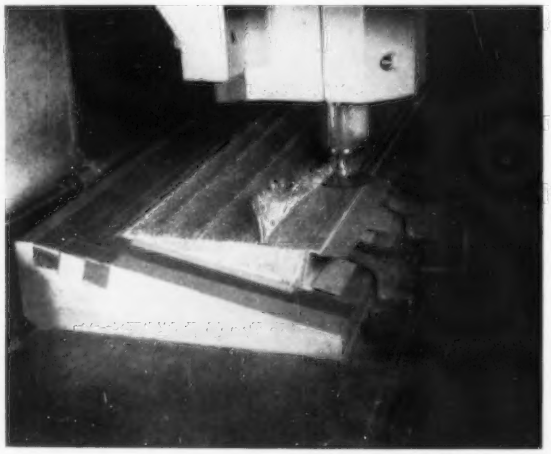
To perform this machining more economically, Northrop Div., Northrop Aircraft Corp. engineers have replaced the use of costly and elaborate horizontal, vertical and spar milling machines with simple, flexible gantry mills and the band saw. The results are:

- Substantial reduction in man-hours (20 to 50 per cent depending on part complexity)
- Improved quality, tolerance (± .005 in.) and reliability of detail parts
- Reduction of scrap (less than 10 per cent)
- Less skilled operators required
- Release of critical machine tools for other work

Polyethylene Glycol for Holding and Reinforcing

Expanded honeycomb material is delivered in rectangular panels of uniform thickness which must be tapered and face-cut to the required shape. First step in this operation is the development of a method for holding the panel in the machine and stabilizing its fragile aluminum ribbons (as thin as .0007 in.) against crushing or edge roll-over. Widespread method in use today is to fill the panel with water and freeze it into a solid for machining. This method has the disadvantage of causing distortion of the core in the freezing and melting process.

Northrop selected polyethylene glycol (polyglycol) as the core-chucking material because of its simplicity and flexibility in use. This material is a solid at room temperature but becomes a waxy fluid when heated to 160-180° F. It is water-soluble, re-usable, and contains no ingredients to contaminate the core material or the



Closeup of trailing edge core panel operation shows previously-bonded skin panel and closing strip channel used to vacuum chuck work in place for final cut. Tape seals grooves in platen to provide vacuum seal.

Northrop SM-62 Snark intercontinental strategic missile, shown here preparatory to launching, makes use of metal-bonded honeycomb panels for light weight, high structural rigidity. Recent announcements indicate that Snark traveled 5000 miles from Cape Canaveral, Fla., to a target near Ascension Island in the South Atlantic.

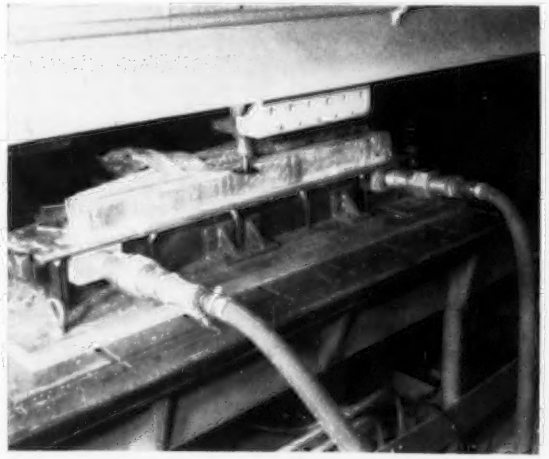
machine—a vital consideration in metal bonding. Polyglycol does not adhere well to smooth surfaces so that its use as a bonding agent to hold the honeycomb face to the chucking surface was questionable. This problem was solved by chemically etching the surface of the chuck to create a rough, porous gripping surface.

Heated to a fluid, the polyglycol is poured on the chucking surface about one-quarter inch thick and the honeycomb panel is pressed down on the chuck. Cold water is then circulated through passages in the under-surface of the chucking plate, solidifying the polyglycol and chucking the core panel for machining.

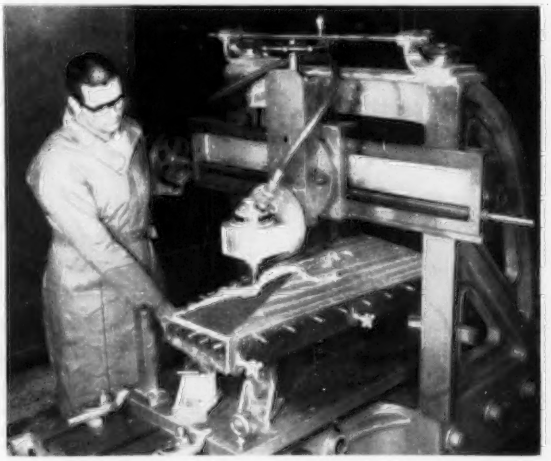
Following machining, the process is reversed. Hot water is circulated through the chucking plate, melting the polyglycol and freeing the machined core from the chuck.

Mobile Heating and Cooling Units

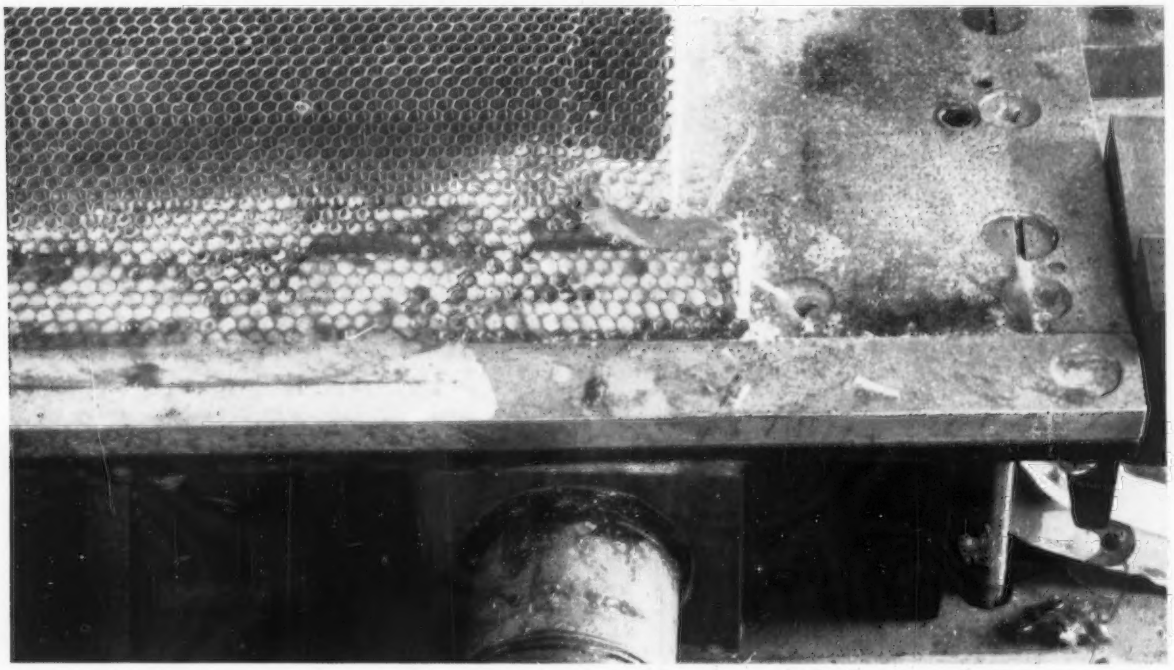
The hot and cold water required for these operations is supplied from a mobile pallet containing an ordinary domestic deep-freeze unit and a commercial home water heater, together with



Closeup of typical setup shows hot and cold-water lines attached to holding fixture. Valve stem cutter removes excess core material while panel is chucked tightly in fixture by solidified polyglycol. Cold water solidifies polyglycol, hot water liquefies it for freeing panel from chuckplates.



Finish machining on multi-plane core panel is done on this converted planer with air-operated motor driving valve stem cutter. First pass removes 0.050 in., second pass 0.030 in. to preserve cutter against abrasive action of splice material.



Closeup of honeycomb core after machining shows solidified polyglycol chucking work tightly to porous holding fixture plate. Hot water line (bottom) melts polyglycol and frees panel from fixture for cleaning and bonding of metal face.

machining honeycomb

circulating pumps, attaching hoses and control unit. This permits moving the supply unit to the various fixed machines as required, and eliminates long hoses scattered about the shop floor.

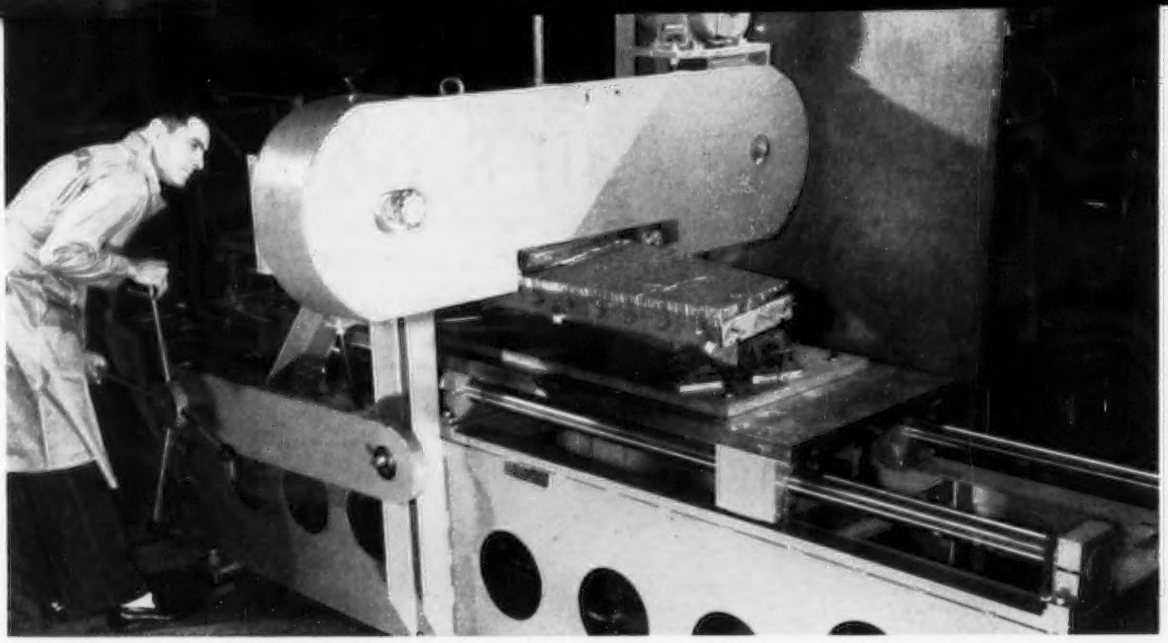
Following freeing from the chucking surface, the core is placed in a hot-air circulating oven at 200-250° F to melt the polyglycol from the interior of the core cells. The material is collected for re-use as it melts. The core is then removed from the oven and cleaned with a hot-water spray, which dissolves any remaining surface coatings. The core is then ready for the normal chemical cleaning process in preparation for bonding.

Roughcut and Finish Machining

Wedged-shaped airfoil surfaces with several planes require that the core ribbons be bonded normal to the surface planes. This requires the splicing of cores at the desired angle prior to machining and bonding. Splice-bonding is effected by Thermofoam and other hardened-foam adhesives which cure into a tough, abrasive joint. Heavy machining of this abrasive would result in frequent replacement of valve stem cutters. Northrop resorted to a Do-All saw for rough-cutting through these spliced panels for the initial facing and taper cuts. The saw is mounted horizontally on a fabricated base, and the tooth-direction reversed from normal operation. The taper and face cuts are made using indexing fixtures and the saw blade is set to gage blocks on the fixture. The core panel is held in place by skewers through side plates.

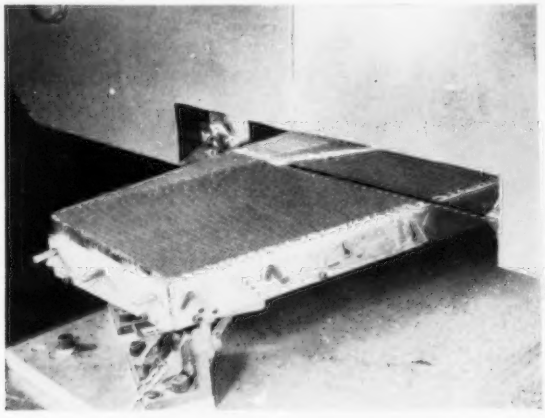
The sawing operation leaves .080 in. to be removed in a finishing operation on both sides to preserve cell direction. A Powell Planer was converted for this operation, the valve stem cutter being driven by a Quackenbush QRC-10 Model 70 air motor. Two passes are made on each face plane, the last removing .030 in., producing a machined core free of burrs or roll-over of the core face. Where recesses are required in the core for ribs or fitting attachment, a hand routing fixture is used and the cut made after all machining operations have been completed. Parts are held to ± .005 in. tolerance without difficulty.

The machining of trailing edge assemblies, requiring only a flat plane cut to provide taper, is performed on a second gantry type mill. The core panel is faced on one side with a false skin and held in the mill on a universal vacuum chuck. After machining, the skin panel, ribs and attaching fittings are bonded in place in an autoclave. The part is returned to the gantry mill and the bonded skin is used to vacuum chuck the part in place, for removal of the false skin. The open face of the core is machined to final tolerance after which the second face skin is bonded in place in the autoclave.

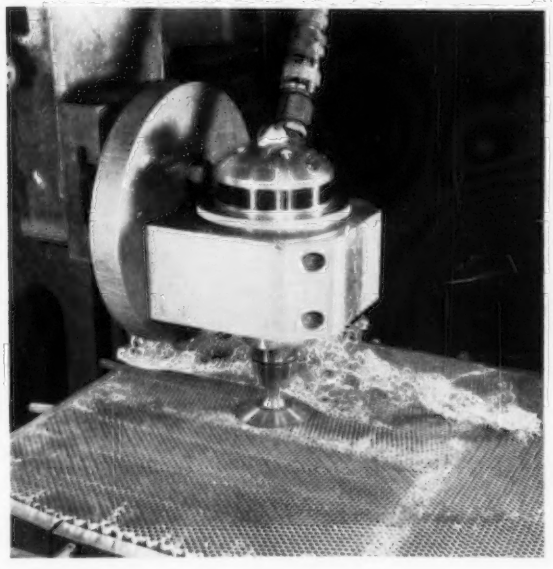


Familiar Do-All saw is mounted horizontally on special fabricated base to slice through tough Thermofoam splice adhesive. Work holding fixture is indexed to desired angle to make taper and face-angle cuts required by part design.

Closeup of band-sawing operation shows cut being made along the length of honeycomb splice. Work is held in fixture by familiar skewers pushed through drilled holes in side plates. Holding fixture supports index core panel to proper angle for taper cut.



The decision of Northrop to enter the subcontracting field two years ago has resulted in the award of major airframe assembly contracts for the Boeing KC-135 jet tanker, McDonnell F4H Navy fighter-attack plane, and the Raytheon Hawk surface-to-air missile. All of these, together with Northrop's own Snark intercontinental strategic missile, use sandwich structures extensively for rudder, flaps, outer wing trailing edge, or aileron trailing edge assemblies. This large volume of metal bonding work has permitted Northrop to develop production equipment specially-tailored for fabricating these units, and has resulted in substantial economies over previous elaborate methods.



Closeup of finish machining operation shows air-operated motor driving valve stem cutter. This is final 0.030 in. cut held to ±0.005 tolerance required for core face preparatory to bonding.

bonding Convair's 880 wings

jetliner wings assembled in massive fixtures
pre-riveted structures bonded to skins to form fuel cells

Optical aligning of station planes assure tool accuracy. Tolerances of .050 in. were maintained in making the heavy tool structure. In fabricating the wing, the pivoting end plate (upper left) is removed from the fixture by an overhead crane. A complete wing is fabricated in the fixture from sub-assemblies produced in other areas of the plant.

Adhesive bonding will be a major fabrication method in the manufacture of the wing sections for Convair's 880 jet transport.

Scotchweld, a nitrile rubber phenolic adhesive, developed jointly by Convair and Minnesota Mining and Manufacturing will be used to bond spars and ribs to the wing skin to create leakproof integral fuel cells.

Elaborate steel work has recently been completed on the six wing buck tooling fixtures, and fabrication of the first wing assemblies will begin in late February.

Each fixture has a length of 90 ft, a width of 10 ft and a height of 22 ft. Three elevations of working platforms will be constructed around each fixture.

The method of assembly will be to attach the center tie box (anchor rib) of the wing to a pivoting end plate on the fixture, install the leading edge spar, intermediate spar, and trailing edge spar and then completely fabricate the final wing in the bonding fixture.

Wing skins will be pre-contured by lift bars that will remain attached to the skin until the adhesive bonding cycle is complete.

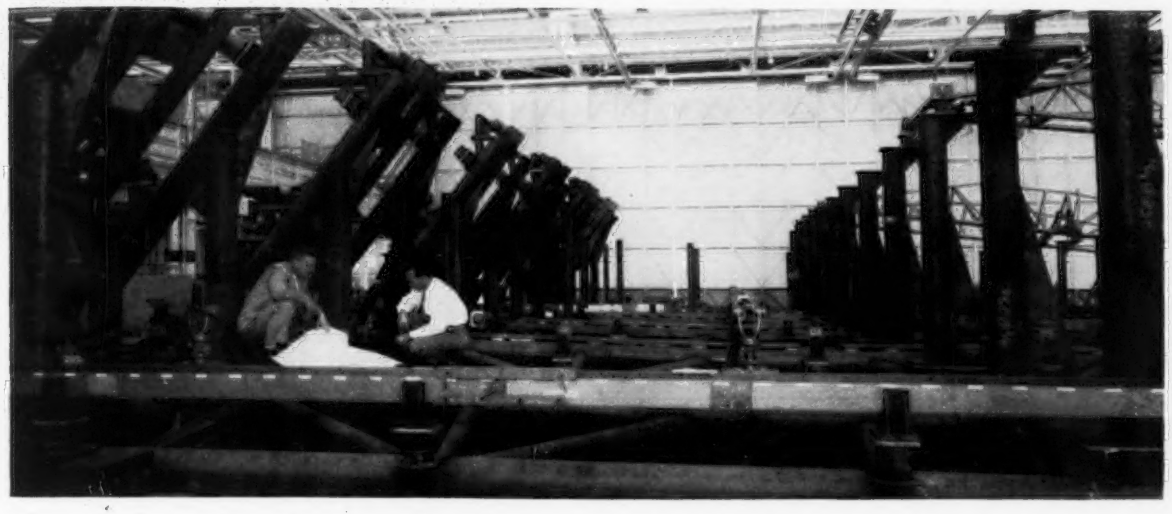
Scotchweld adhesive tape is placed between all faying surfaces, and the surfaces are clamped at 100 psi prior to any drilling which is done in the fixture. This is done to preclude contamination of the bonding area once the parts have been chemically cleaned.

Convair has had considerable success with combination riveted, adhesive-bonded joints and it is assumed that much of the drilling done on parts in the wing fixture would be to effect this type of joint. Combination riveted, adhesive bonded joints have higher, and more uniform tensile and peel values at temperature extremes than either the riveted or the adhesive bonded joint.

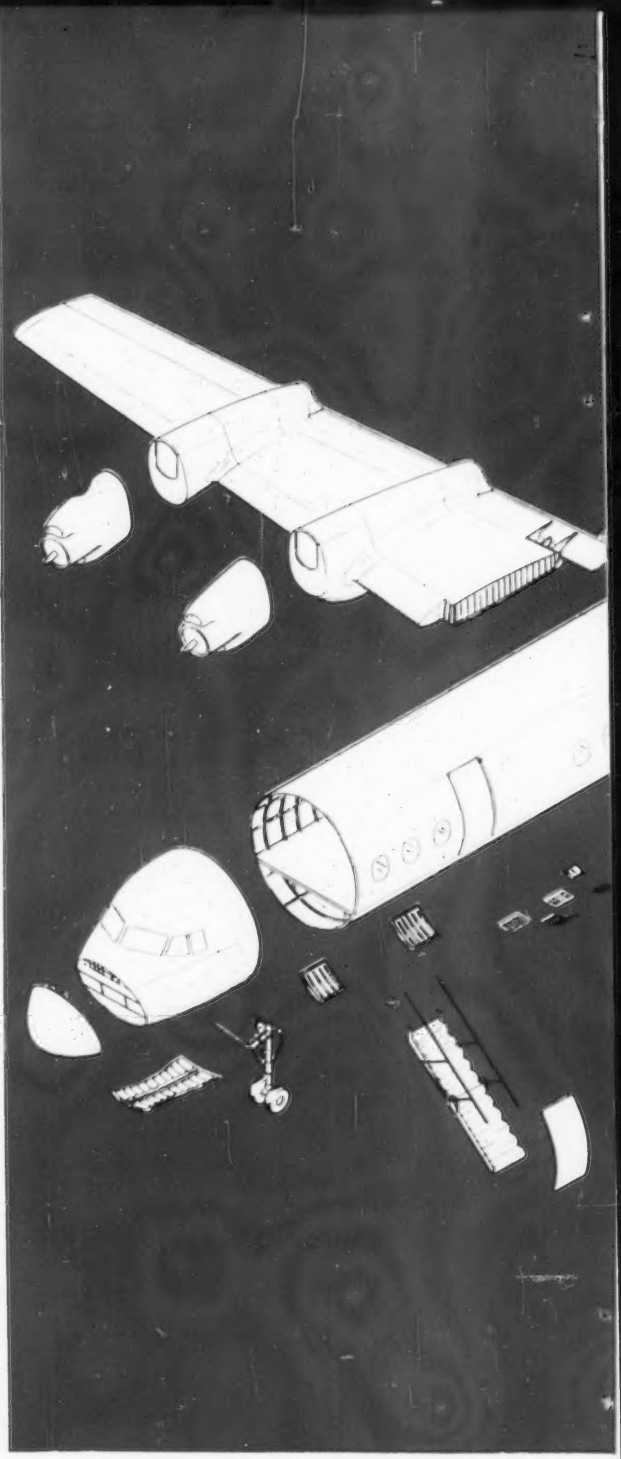
Curing of the Scotchweld on the 880 wing assembly will be effected in an electric oven measuring 80 x 20 x 10 ft. The cost to build the production bonding area, complete with metal processing tanks and craneways was $680,000.

One of six 90-ft wing bucks to be used in assembly of the 880 jet transport at Convair-San Diego. Convair tooling engineers report these are the largest wing bucks ever made for a Scotchweld adhesive bonding assembly.

Half the length of all six wing bucks, three right hand and three left hand, is shown. Each weighs 75,000 lb and is welded from heavy tubular steel.



producing the ELECTRA



concept

planning for Lockheed Electra emphasizes design for producibility

guarantees

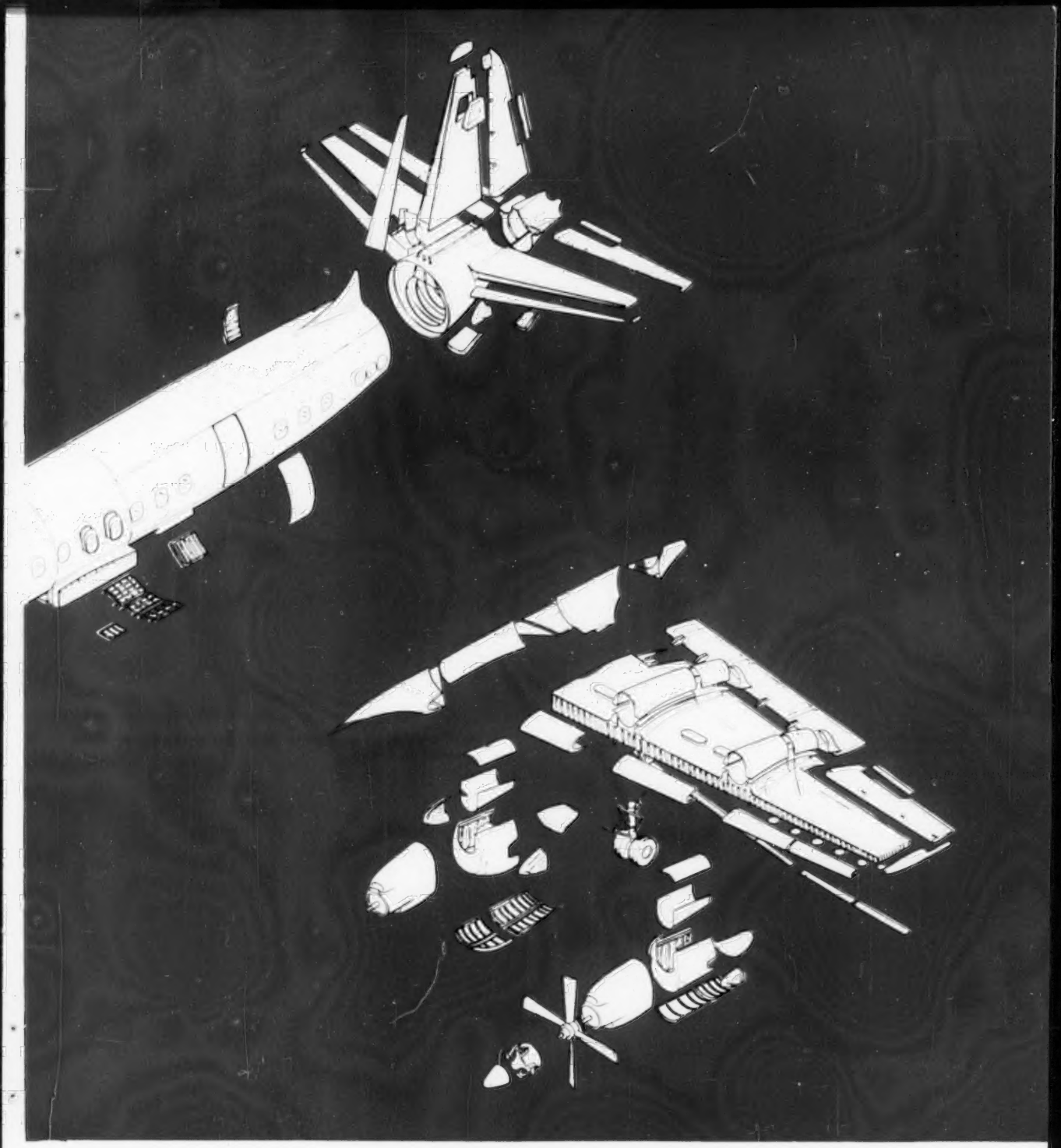
agreements made two years ago kept firm for performance, price, and delivery dates

reliability

fail-safe design embraces multiple load paths and reduced working stress levels

by **Robert McLarren**, Executive Editor

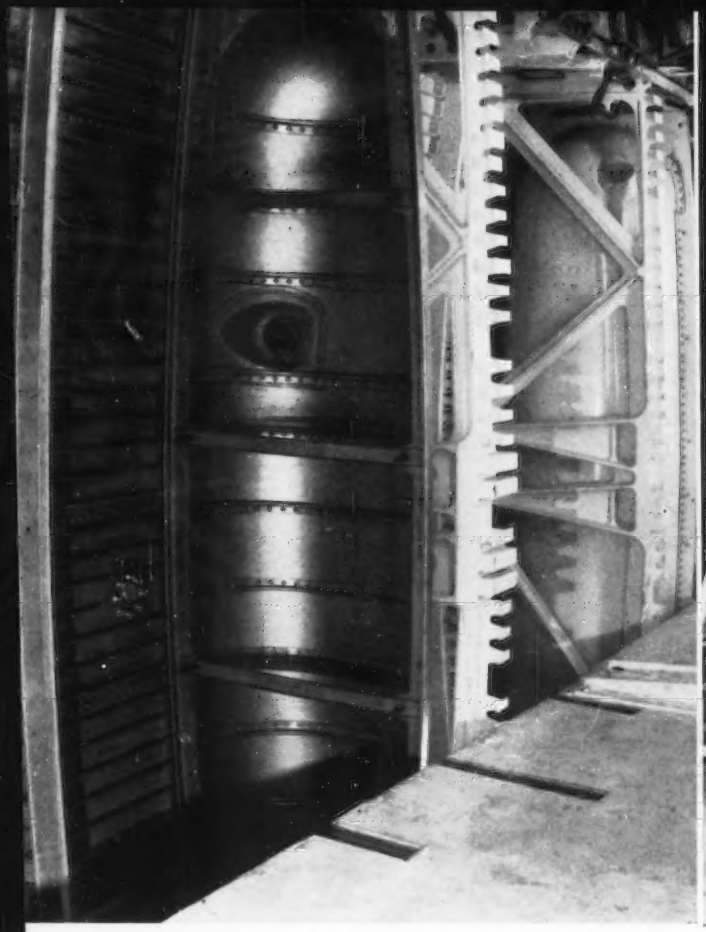
The Lockheed 188A Electra, America's first production turboprop transport, is being delivered with the exact performance, selling price, and delivery schedule established two years in advance by the firm's commercial sales depart-



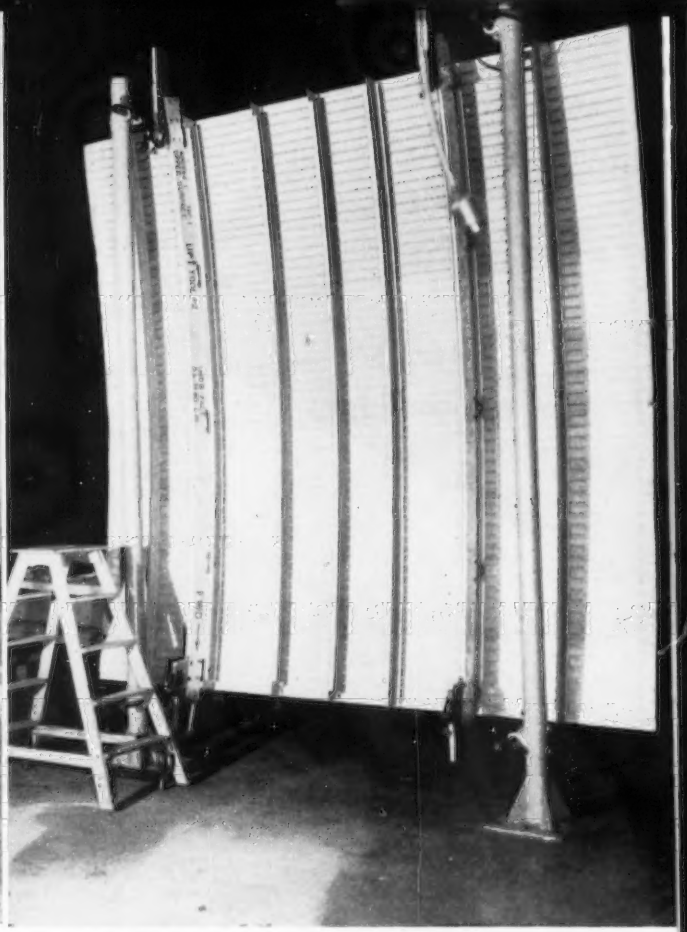
ment. Within those two years lies a story of continuing technical achievement on the introduction of the most advanced design principles, materials, and fabricating methods available while holding firm to weight, cost, and delivery guarantees.

Weight Control

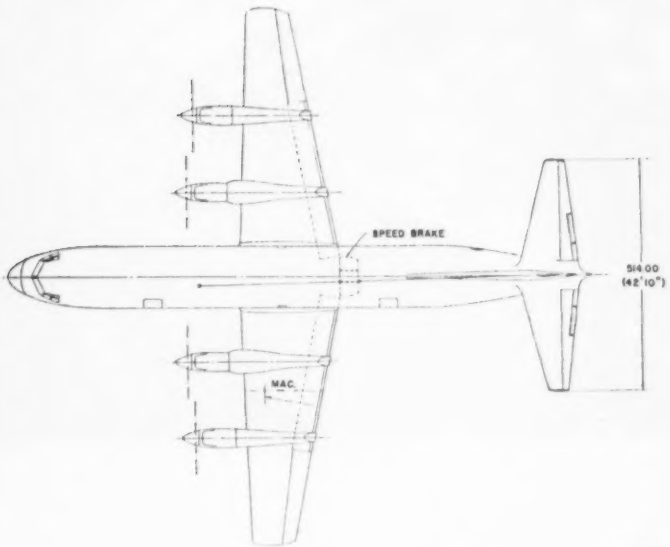
The re-design sweated, 3000 lb out of the empty weight, a saving of six per cent, while preserving intact the design load factors and structural integrity. This major weight-saving feat

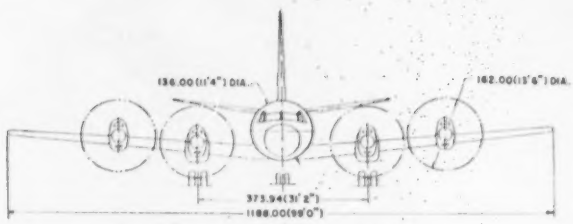


Integral fuel tank ends are concave and are spaced 12 in. away from main landing gear fittings as safety measure.



Integrally-stiffened wing panel with nine segments attached by internal fastening.





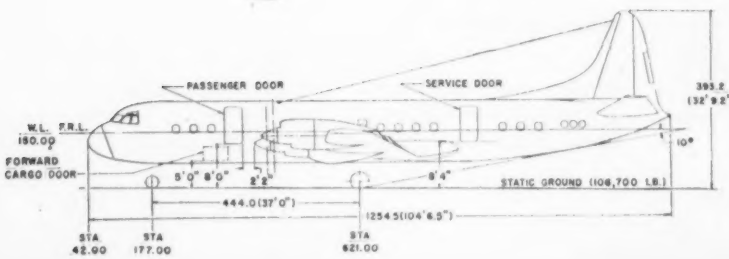
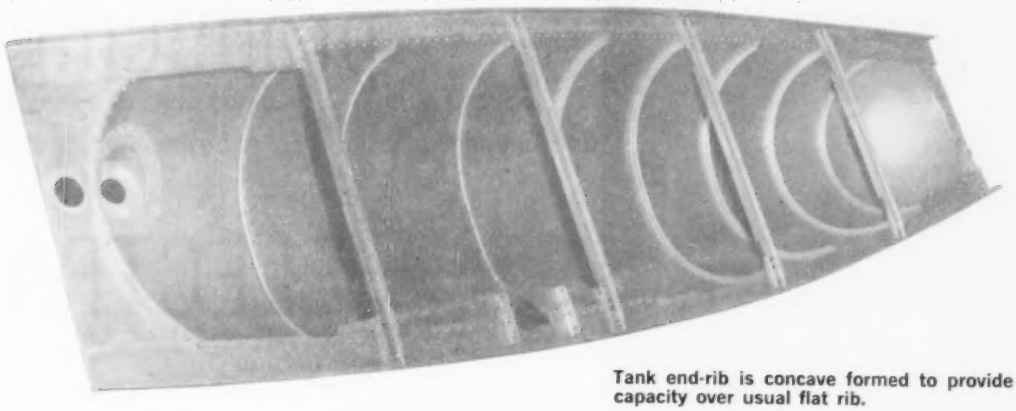


TABLE I

Technical Data

Wing Span	99 ft
Overall Length	104 ft. 6.5 in.
Height Over Tail	32 ft. 1 in.
Empty Weight	55,993 lb.
Gross Weight	113,000 lb.
Wing Area	1,300 sq. ft.
Power	Four Allison 501-D13 (ea. 3750 ESHP @ 13,820 rpm.)
Fuel Capacity	5,360 gal. kerosene
Cruising Speed	405 mph. @ 22,000 ft.
Range	2,295 mi.
Passengers (standard)	85
(custom)	66



Tank end-rib is concave formed to provide additional fuel capacity over usual flat rib.

producing the ELECTRA

was performed while adhering rigorously to a "fail-safe" design principle, a subsequent increase in wing area to meet a post-design CAA short-field requirement, and the use of decisive reductions in working stress levels. These requirements, exerting pressure towards increased weight, were met by virtual integration of design and manufacturing functions through liberal use of:

- Integrally-stiffened skin panels
- Chemical milling
- Large forgings
- Plastic materials

Integrally-stiffened skin panels eliminate countless extruded angle stiffeners, splices, doublers, bolts and rivets and, in the case of integral fuel tanks, the weight of sealants. However, the comparatively wide tolerances demanded by extrusion techniques, together with the need for subsequent straightening, necessitates extresive machining of the skin panels with its attendant costs. Chemical milling is finding accelerated usage in airframe fabrication because of its extremely close-tolerance qualities and its ability to remove metal in the precise areas and thicknesses desired. However, it has size limitations; also, its characteristic undercutting beneath the protected surface is objectionable.

Electra uses for its nose landing gear support structure, two of the largest forgings ever installed in aircraft. The largest precision forgings utilized to date in aircraft are used in the new transport for window frames. Widespread use of plastics for the cabin interior also provided important weight savings and manufacturing simplicity, particularly the use of reinforced plastic ducting.

'Fail-Safe' Design

The use of high-strength aluminum alloys, such as 7075 ST, has given rise in postwar years to the spectre of fatigue failure, now an intimate part of aircraft design problems. The historic case of the deHavilland Comet revealed stress concentrations at window corners as the culprit. Conventionally designed structures can propagate a crack in such a "stress raiser" directly across the skin to explosive failure. Lockheed adopted a "fail-safe" design philosophy from the outset of structural design of the Electra, so that failure of any part (including a skin crack 12 in. long) cannot lead to failure of the complete airplane. This philosophy embraces multiple load paths, reduced stress levels, and fewer, larger parts.

Typical "fail-safe" technique is the use of one-piece precision forged window frames and chem-milled door frames. In these critical parts the traditional doubler is replaced by forged or chem-milled "lands"; thickened portions providing the increased cross-sectional area without the riveting of doublers. These "lands" provide the increased area and consequent reduced stress through the ideal load-transfer characteristics of solid metal, as compared to the traditional doubler technique in which rivets must make the transfer.

Windows are of stretched Plexiglas, the material prestretched in two directions by Rohm & Haas to render it crack-proof. For example, a bullet will make a neat hole in the material without shattering it.

The working stress level of the cabin expressed as hoop tension loads on the frame rings is held to 12,000 psi as a result of an extensive fatigue resistance program by Lockheed research.

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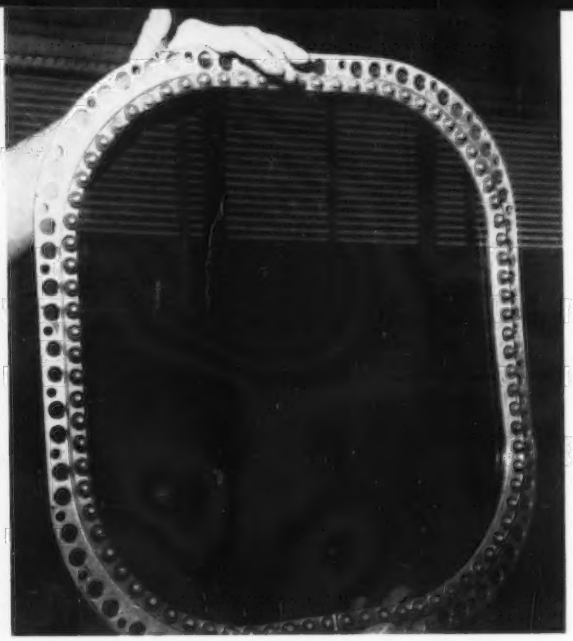
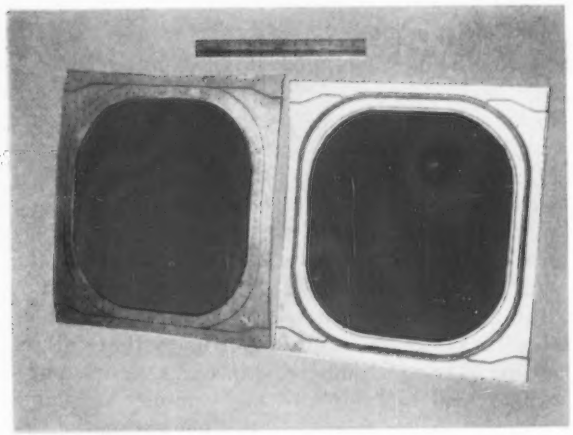
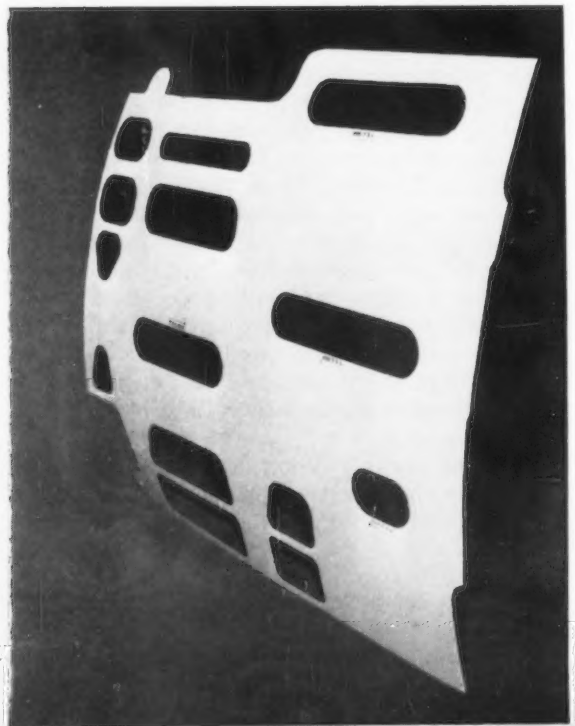






producing the ELECTRA

Assembly Breakdown

Understandably, the Constellation aircraft served as the reference point-of-departure for both the engineering and production of the Electra. For example, the wing of the Electra follows closely the design and production principles developed on the Model 1649 long-wing "Connie" which pioneered the extensive use of integrally-stiffened skin panels on commercial aircraft. Conversely, the manufacturing breakdown of the "Connie" into a series of six transverse "barrels" (determined 15 years ago) has been abandoned in the Electra in favor of longitudinally-sliced panels.

This latter decision expresses a basic manufacturing principle used in the new turbo-prop transport: "stuff" early, or make functional installations as early in the assembly sequence as possible. Some equipment items are installed as early as the detail part stage but most in the sub-assembly stage. This solves a variety of problems developed through "Connie" experience by:

- Eliminating "subway jams" of workers in the final assembly stage
- Avoiding the difficult accessibility for installations in the completed fuselage or wing
- Eliminating rework and modifications to incorporate customer requests in a standard structure

TOP:

Stretched "Plexiglas" windows are crack proof.

CENTER:

Forged and chem-milled window frames.

LEFT:

Chem-milled doubler supports turbulence air loads in bottom fuselage speed brake area when brakes are extended. Note raised "lands" around cutouts to serve as doubler thickness for edge support.

Integrated design, compact assembly facilities, and automatic riveting help telescope manufacturing time

Design and production were integrated smoothly in the Electra project in the form of a production-design-engineering function organized directly astride both departments. Every drawing for the new airplane has been signed-out by production-design-engineering, signifying that it meets engineering and producibility requirements.

The Electra manufacturing breakdown was determined using the time-in-process concept. For example, there are 44 assembly stations requiring 138 days to complete a Model 1049A Constellation. This sequence has been reduced to 33 assembly stations requiring only 88 days to complete a Model 188A Electra. This reduction results from the use of fewer parts, production methods utilizing the "stuff" early principle, extremely compact assembly facilities, and automatic riveting techniques.

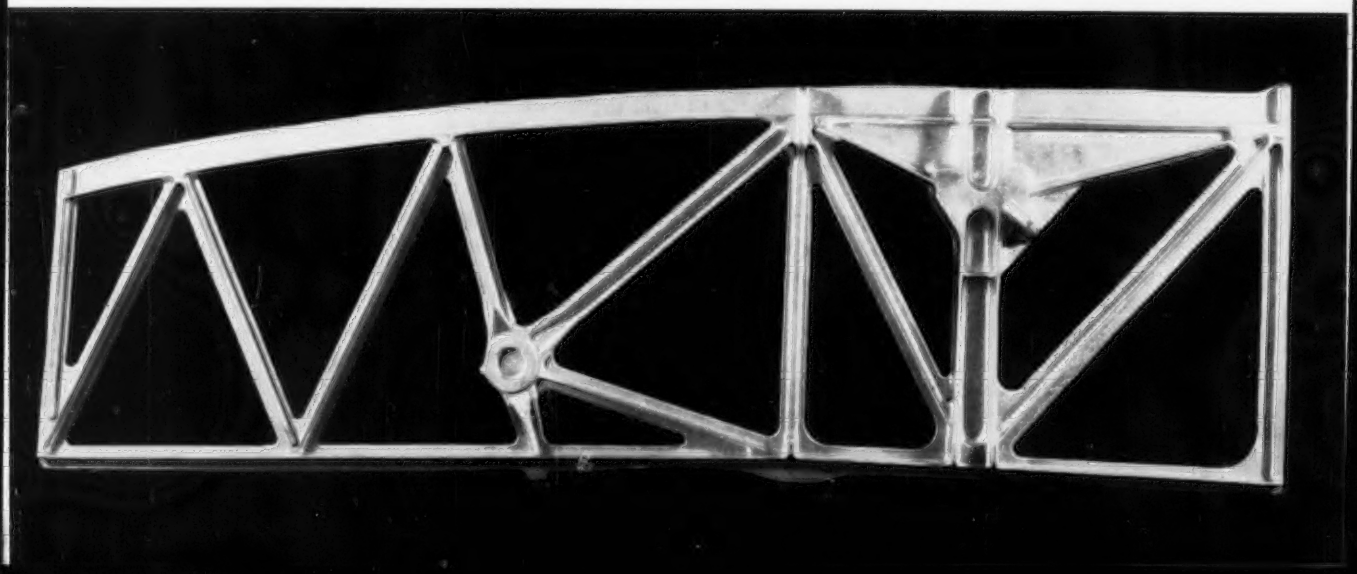
Wing Structure

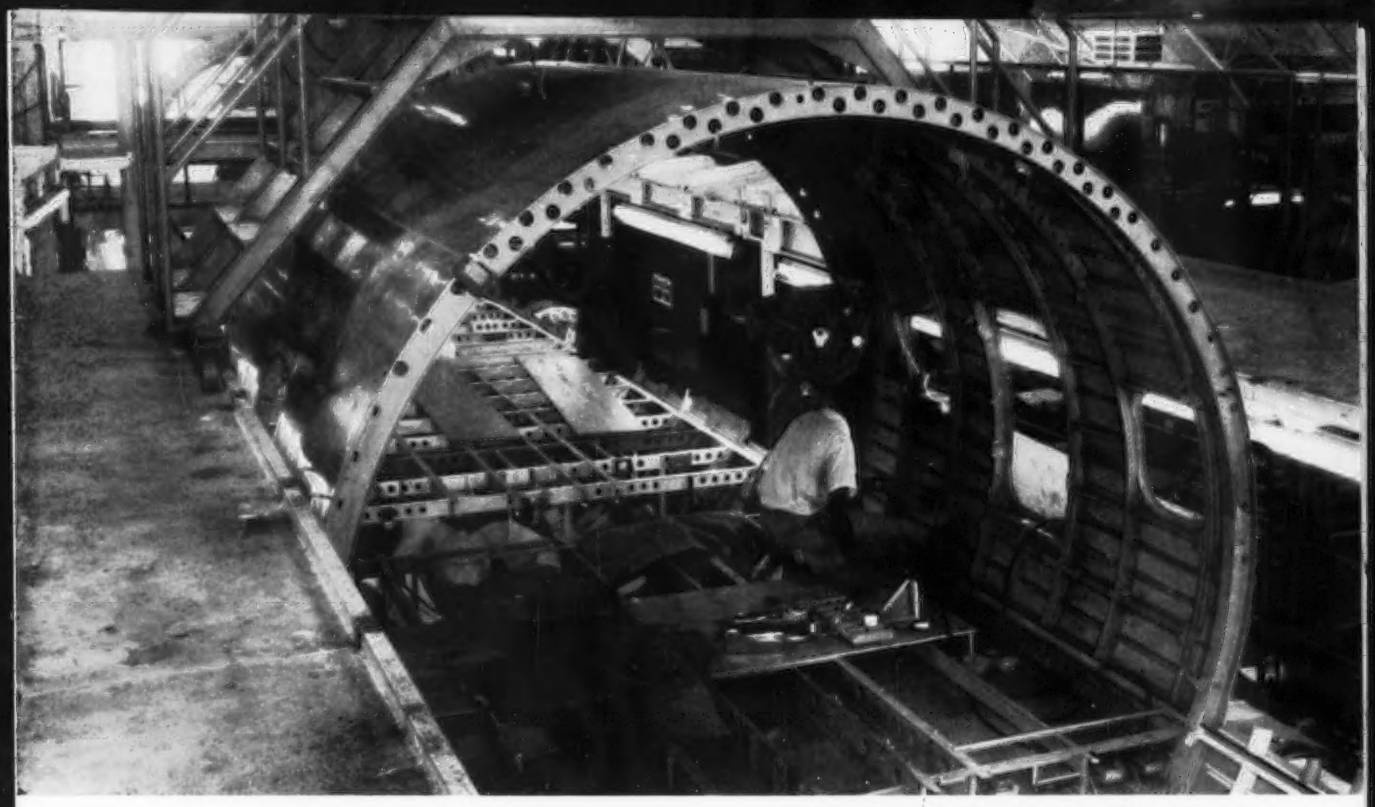
The Electra wing is made up of a center section comprising the fuselage mid-body stub wing as an integral unit, two wing panels, and two wing-tip assemblies. Wing panels are conventional box beams with solid webs and extruded spar caps. Truss-type ribs are used with formed rib chords and bulb-angle truss members. Wing skin panels are of integrally-stiffened aluminum alloy. The lower skins utilize 7075 and the upper skins 7178; the latter selected for its superior compression characteristics. These skin panels are made from 15 in. width tapered extrusions incorporating seven stiffener legs. The skin tapers from .080 in. at the root to .040 in. at the tip, with pads up to .150 in. thickness. The extruded panels are furnished from the supplier with standard extrusion tolerances and require complete over-all machining to meet the ± .010 in. tolerance specified. These strips are formed to airfoil contour by shot peening and then heat treated. Due to the 15 in. width limitation of the extruding dies, a complete wing skin panel is made up of nine spanwise plates attached along spanwise joints by shear-type Huckbolt fasteners.

The rib-to-skin attachment problem follows the principle of tying the ribs to the skin stiffeners wherever possible to eliminate chordwise riveting thus avoiding contour tolerance and tank sealing problems. The attachment is made with an "H" clip which nests between, and is riveted to, two stiffener legs. Clips are used in alternate stiffener channels. The rib-to-clip attachment is then made with a flat tab riveted to the rib chord and to the back of the clip.

The simplicity of this method is deceiving since clips are cut from extruded stock. The costly machining of these clips to the required ± .003 in. tolerance was avoided by use of a longitudinal bead in the extrusion, along the cross of the "H." The clip is placed in a punch press between two

Electra nose gear support fitting is largest forging used in aircraft to date.





Fuselage assembly dock shows mid-body stub wing cell in place. Quarter panels are added to complete assembly.

producing the ELECTRA

end plates. The bead is struck by the punch, resulting in the expansion of the cross. This forces the legs of the "H" to the exact width within the specified tolerance.

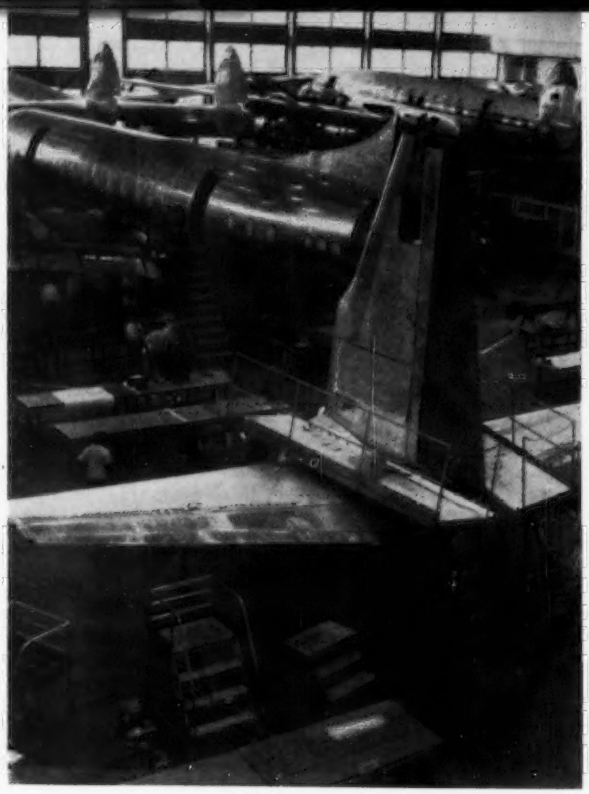
Rear spar of the wing is an integral part of the wing trailing edge assembly. The skin panels are tied to legs of the spar cap extrusion by Huckbolt fasteners. Wing leading edge segments are hinged and their fastened edge is protected against abrasion of the spar cap by rub strips. All fairing panels in the wing-to-fuselage juncture are similarly protected.

Integral Fuel Tanks

The integral fuel tank is a traditional weight-saver for the aircraft designer, but service difficulties have plagued such designs for 20 years. Lockheed experience with the Constellation, backed by extensive research has culminated in the use of integrally-stiffened wing panels throughout the tank area and the practice of avoiding attachments through tank surfaces. The entire wing box beam is an integral fuel tank with the exception of the main landing gear area. Lockheed engineers have kept the tank area 12 in. away from the main landing gear area on both sides to minimize the possibility of the gear being driven up through the tank in an emergency landing. Secondly, fuel capacity is increased by forming the tank terminal ribs into convex bulges rather than flat.

Upon assembly of the wing structure, the fuel tank areas are chemically cleaned, and joints are hand-sealed with Thiokol polymerized rubber compound. Hot air is then circulated to accelerate sealant curing. Tank exteriors are then coated with a detergent solution, tanks are pressurized by air, and leaks are detected by bubbling.

The wing is filled with Buna N liquid syn-



Aft fuselage segment has integral fin and stabilizers as a single replaceable unit.

thetic rubber compound, drained, and hot air is pumped through to cure the coating.

Mid-Fuselage

The fuselage is a perfect circle of 11 ft 4 in. diam, and is pressure-sealed throughout. It is built up of frames 19 in. apart, with stringers every five in., and covered by flush-riveted exterior skin.

Fuselage material is 7075 aluminum alloy throughout.

The circular frames are segmented, and hydropress formed from sheet stock. Lockheed has reduced scrappage here by cutting the sheet into straight strips, stacking them into a bundle, and stretch-forming the bundle in the plane of the material to produce the required segments. The flanges are then formed and lightening holes cut in the conventional manner.

Stringers are "J" section extrusions varying in thickness from 0.25 to 0.71 in., depending on local loading conditions. Fuselage skin is 2024 ST aluminum alloy selected to support the varying pressurization loads against fatigue failure. Skin panel thickness is .040 in. from the nose rearward to the mid-body stub wing, where it is increased to .05 in. due to the increased loading in this area. Panels are .040 in. aft of this segment.

The fuselage is assembled from forward and aft assemblies mated to the mid-body stub wing segment. Each of these three major assemblies is divided into circumferential quarters (i.e., top panel, two side panels containing the windows, and a bottom panel). The bottom panels, containing the floor supporting structure, are further divided into two lengthwise slices to facilitate automatic riveting. Frame segments and stringers of each "canoe" are located in an assembly jig, and skin panels are tack-riveted into place. A heavy contour bar located at each end of the panel stabilizes the tacked unit and provides a holding guide for automatic riveting. General Drivmatic units are used with both tape and punched-card control depending upon the complexity of riveting patterns.

Following riveting, the "canoe" segments are assembled, and the floor frames installed into a complete quarter panel. At this point, the installation of functional items begins and continues through the remainder of the assembly operations. The completed quarter panels then go into the mid-fuselage assembly dock where the fuselage is integrated.

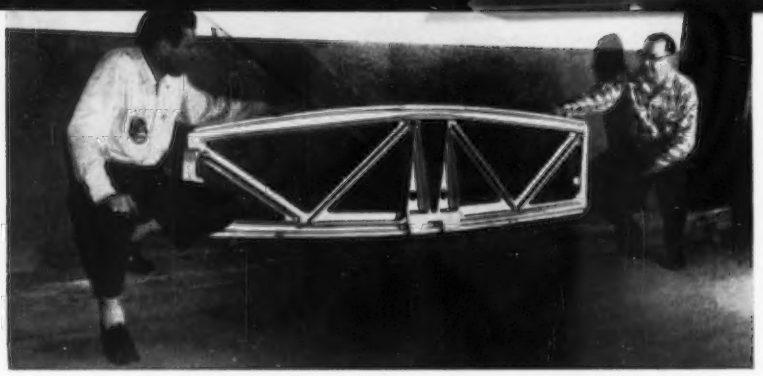
Lockheed has used faying surface sealing, for the first time, on the Electra, by coating with Thiokol polymerized rubber compound paste to which a suitable catalyst is added. The treated contacting surfaces are then riveted through. Hand filleting is used along joints, and the sealant is cured at room temperature.

Upon completion of the mid-fuselage assembly, it is moved directly into a pressurization checking dock. The aft pressure-seal bulkhead having been installed, a huge formed-steel concave end-plate fixture is applied to the forward end, and the fuselage is pressurized to 7.1 psi. It is interesting to note that workmen continue their activities inside the fuselage during this check, applying silicone filleting as required by leakage. In this process even a minute leak identifies itself by an ear-piercing hiss. When the minimum permissible leakage rate of 65 cfm at 6.5 psi is achieved, the fuselage is hoisted from the dock into an adjacent mating dock.

Forward Fuselage

The forward fuselage is handled as a separate major assembly since the design of the airplane incorporates an independent flight station

producing the ELECTRA



Main landing gear support forging

with its own separate Freon evaporator, recirculating fan, and electric heating elements. The forward fuselage consists of a lower flight station assembly and a cab top; the latter including all transparent panels. Windshield panels are removable from the outside to facilitate service replacement. The instrument panels are hinged. The nose landing gear well and the access panels through the radar bulkhead provide space for the installation of the myriad functional items in the flight station without crowding the cabin entrance door area. The forward fuselage is sealed and pressure-checked in its own pressure dock through the use of a large formed end-plate fixture containing the air lines. The forward fuselage segment is then mated to the mid-fuselage through a circular channel tension joint.

Aft Fuselage

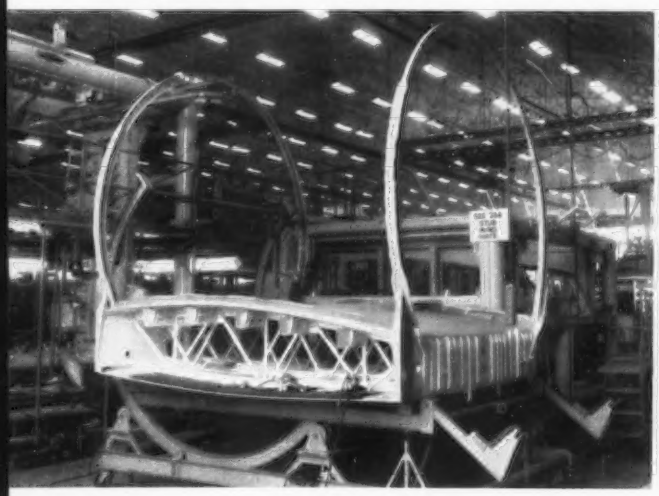
The aft fuselage, fin, and horizontal stabilizers are assembled as an integral unit. This break from military practice requiring separate interchangeable assemblies effects simplicity and savings. Aft fuselage framing units are chem-milled to produce exact thicknesses with minimum weight. The fin and stabilizers are covered with tapered skins varying from .10 in. at the root to .03 in. at the tip. Upper and lower skins are 7075 aluminum alloy.

The aft fuselage is joined to the mid-fuselage through a simple tension joint. A tail cone unit is fabricated as a separate assembly and joined to the aft fuselage segment. The completed fuselage is then moved to a separate paint hangar for lacquer painting of required airline motif.

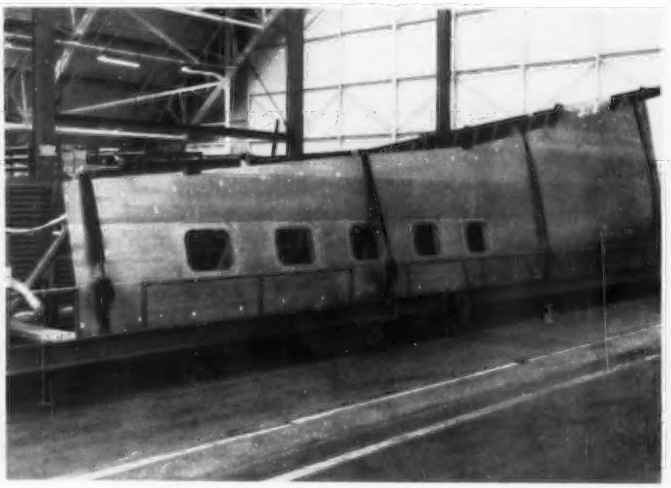
Control Surfaces

The high strength of the 7075 Alclad alloy reduced the thickness requirements for control surface skins to only .016 in. These skins are stabilized by a corrugated inner skin of .016 in. on rudder and ailerons, and .012 in. on the eleva-

Mid-body wing cell is central structural member which joins fuselage sections and wing panels.



Complete lower wing skin is integral unit ready for installation to front and rear spars in wing assembly jig.



tor. This latter skin proved difficult to form by hydropress due to sticking of the pads and resulting distortion of the precise corrugated form. Lockheed solved this problem by forcing hydraulic fluid under high pressure against the skin and its supporting form block to produce the desired contour.

Plastics

The Electra makes more extensive use of plastic materials than perhaps any previous Lockheed airplane. Injection-molded melamines are used for such escutcheon parts as the "gaspers" (cold air inlets), light switch, and stewardess-call panels above each window passenger seat. Some of the ducting consists of vinyl plasticol, made in a slosh molding over plaster breakaway forms; other is of glass cloth polyester laminates. DuPont's nylon Zytel is used for molded parts in the flight station including throttle quadrants.

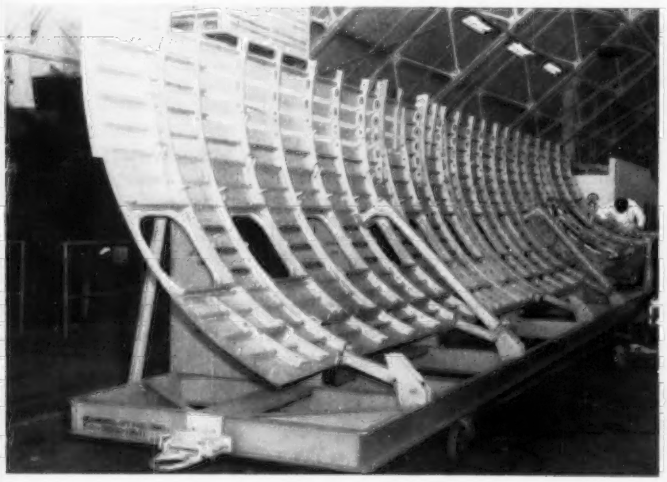
While these parts are purchased from vendors, Lockheed maintains its own extensive plastics shop and produces such parts as electrical junction boxes (including the large main junction box), benches, dispensers, ducts, and trim components in lavatory compartments. Lockheed has also developed a method of fabricating a preform from chopped glass fibers. This material is purchased in rope form which is chopped into two-inch lengths and entered into a vacuum chamber. The air is drawn out of the chamber through a perforated form, adhering the chopped fibers to the form. This is then coated with a polyester and molded under heat and pressure to form the window reveals.

The Electra utilizes radiant cabin heating through the use of resistance wiring in the lower cabin walls and the complete floor. The heating element wires are covered with silicone and a braid wrap and pressed into the edge face of an aluminum alloy honeycomb panel in a sine wave pattern. This is then covered with a bonded surface sheet. The edges of the panels are sealed by syntactic foam. Fiberglas padding and decorative vinyl are attached to complete the trim panels.

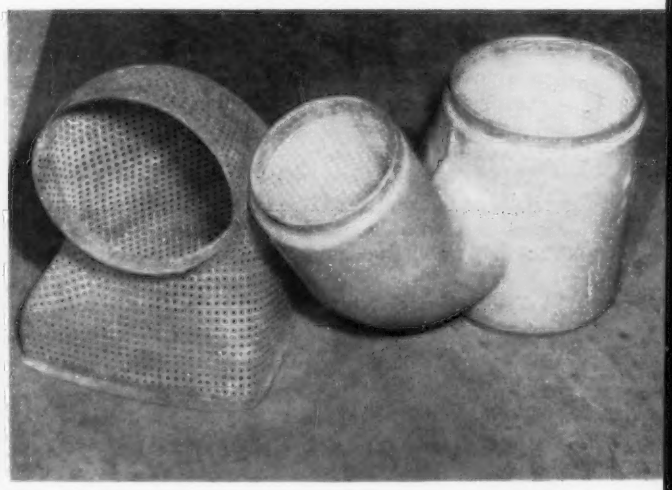
Subcontracting

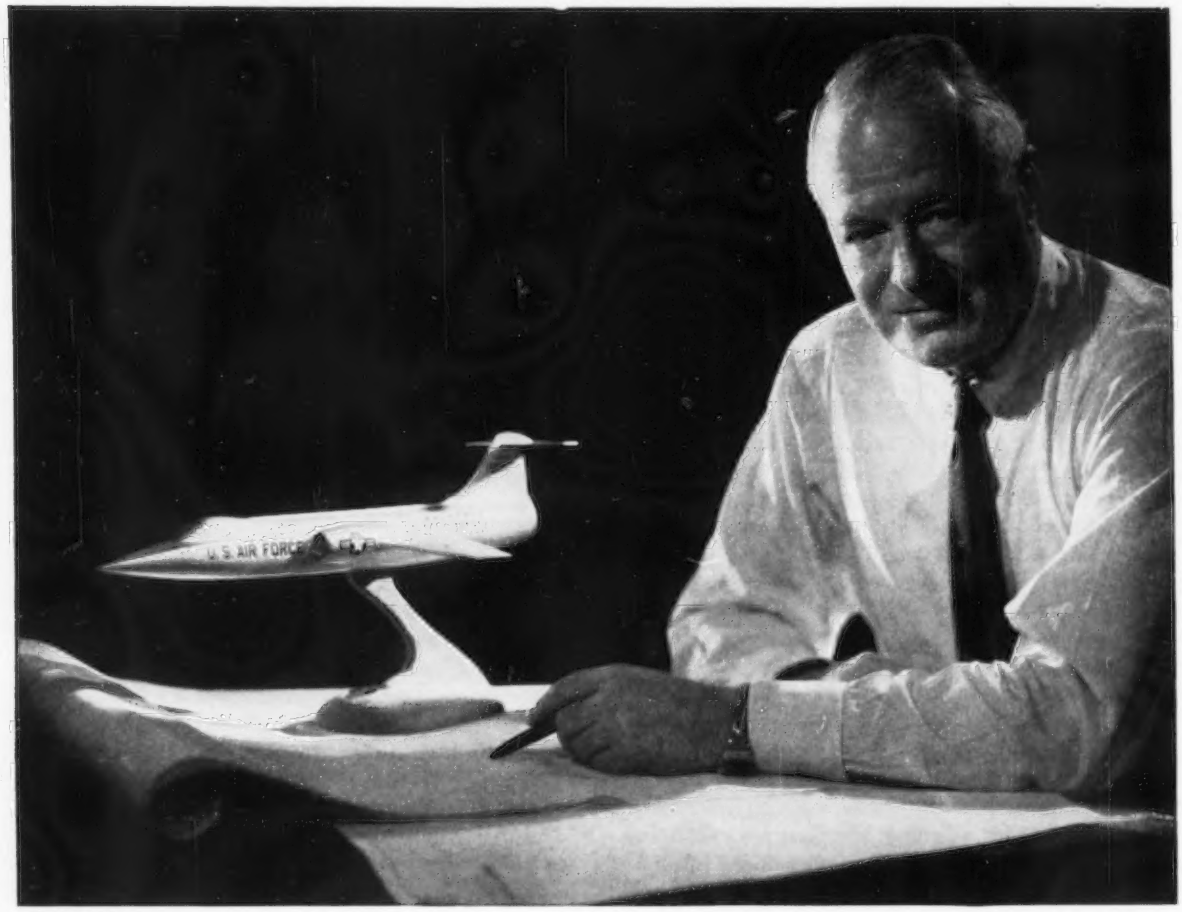
Lockheed has followed military practice in the subcontracting of major assemblies to a greater extent than in any previous commercial project. This has generally included detail design as well as fabrication of assemblies. The complete empennage design and manufacture was subcontracted to Northrop Aircraft at a time when that company had design time and facilities available. Following completion of design work, Northrop found itself unable to undertake manufacture, and this was transferred back to Lockheed. Temco is supplying complete ailerons, flaps, wing tips, and wing leading edge assemblies. Menasco Mfg. Co. furnishes both main and nose landing gear complete assemblies. Rohr Aircraft Corp. delivers complete engine nacelles, demountable power units, and tailpipe assemblies.

Fuselage quarter panel is assembled by automatic riveting. Skin is 2024 aluminum; frames and stringers are 7075.



Perforated prepreg glass fiber ducts.





ROBERT E. GROSS

Portrait by Fabian Bachrach

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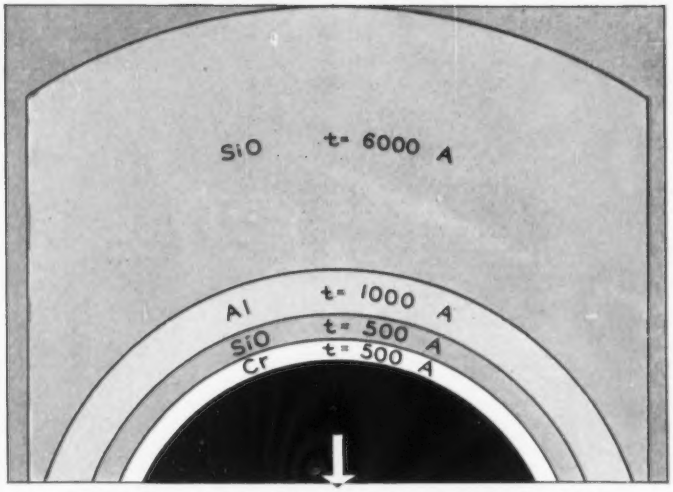

SiO t= 6000 A
Al t= 1000 A
SiO t= 500 A
Cr t= 500 A
COPPER FLASH, COPPER PLATING, SILVER PLATING, AND GOLD PLATING ON 0.028 IN. AZ-31 MAGNESIUM ALLOY

FIG. 1: Multi-layer evaporated coatings and corresponding thicknesses developed to effect optimum visibility, durability, and temperature stability of the Vanguard satellite.

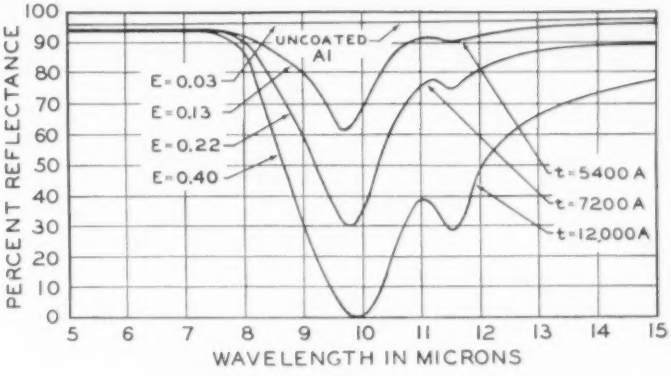


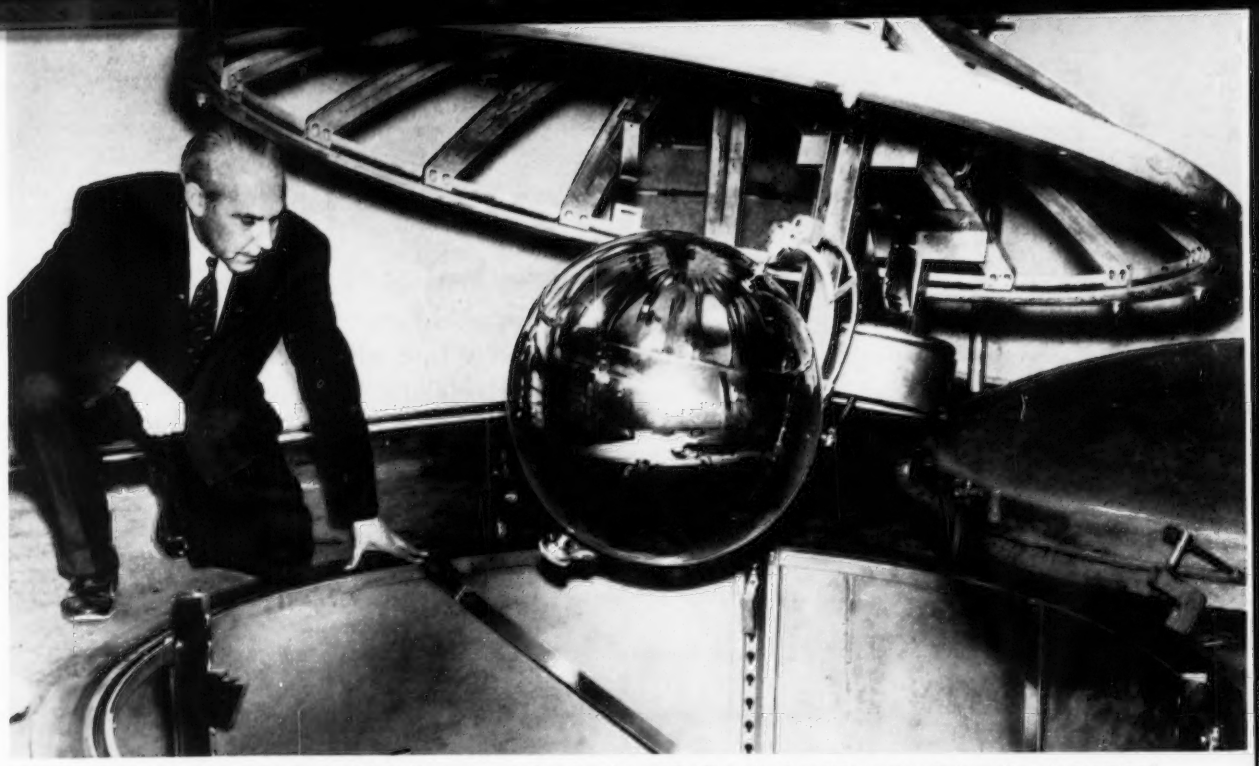
FIG. 2: Infrared reflectance and heat emissivity (at 20°C) of Al with and without SiO coatings of various thicknesses. Coating thickness is expressed in Angstroms, and emissivity in ergs per second.

surface coatings for Vanguard satellite

The surface of the Vanguard earth satellite must satisfy two basic requirements: it must have a high degree of reflectivity in the visible spectrum for photographic and visual tracking; it must have the proper ratio of absorptivity to emissivity in the infrared spectrum for temperature stabilization. Micro-thin platings of aluminum and silicon monoxide (SiO) on the satellite's surface contribute most to satisfying these requirements. Six other coatings are applied as a base in preparing the surface to receive the aluminum and SiO. The combined thickness of the final two coatings is .000027559 in.

A total of eight separate plating operations were involved in the manufacture of the initial order of 12 Vanguard satellites. The first four coatings were applied by the manufacturer, under conditions much less exacting than the final

multi-layer plating measuring less than .00003 in. controls critical



Vanguard satellite ready to be lowered into the vacuum chamber for application of micro-thin evaporated coating, is examined by Dr. George Haas, Chief, Physics Research Laboratory, Fort Belvoir, Va.

four critical coatings applied by the Naval Research Laboratory.

The 20 in. satellites were made in halves from AZ-31 magnesium alloy, deep drawn from a .091 in. blank at 650° F, and machined to a .028 in. thickness. After preliminary cleaning and polishing, a copper flash, copper plating, silver plating, and gold plating were applied respectively by Brooks and Perkins at their plant in Livonia, Mich. Machine and hand buffing to a high luster followed each operation. A strippable plastic coating was also sprayed on the sphere as a protective finish before shipping to Fort Belvoir, Va. Here, the final four coatings were applied in the research and development laboratories.

To provide uniform coating and preclude surface roughness, a device was contrived to support and rotate the spheres in a manner to expose all portions of the surface for equal deposition. A masking device was incorporated between the plating source and the sphere, to limit the angle of incedence of the material to be deposited to 45 deg or less.

After subjecting the sphere to a gas discharge for final cleaning and heating, coating of evaporated chromium, silicon monoxide, aluminum, and a second surface layer of SiO were deposited. Chromium was used as the prime coat atop the gold plating because of its excellent adherence properties. The silicon monoxide which followed was used as a barrier layer to prevent molecular diffusion between the chromium and the reflecting layer of aluminum. The final coating of SiO was used to provide a hard, transparent protective film.

Coating Thickness Expressed in Angstroms

The initial four platings applied by the manufacturer are measured in ten-thousandths of an inch, but the final evaporated layers are so thin that their thickness has to be expressed in Angstroms. (An Angstrom is equal to one hundred-millionth of a centimeter, or, 3.937 x 10-9 in.) See Fig. 1.

Laboratory calculations showed that to achieve the temperature stability required the SiO coated aluminum should have an average reflectance of about 82 per cent over the entire infrared range. To reach the emissivity to absorptivity ratio desired, the silicon monoxide was applied in a thickness of 6000 Angstroms. Figure 2 shows the reflectance of SiO coated aluminum as a function of wave length for certain thicknesses. The greatest variance is noted in the 10 micron wave length area. This dependence of infrared reflectance on SiO thickness allows accurate control of the amount of heat radiated by the satellite.

absorptivity to emissivity ratio

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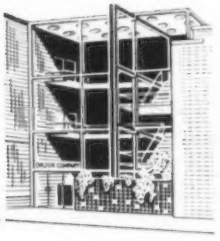

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Top and bottom views of a molded, phenolic-asbestos, turbine wheel from a Navy infrared homing missile. The turbine wheel is finish machined by conventional methods after removal from the mold.

Retaining rings, washers, control cable pulleys, and sleeves are representative of the variety of small heat and wear resistant phenolic-asbestos parts finding application in aircraft and missiles.

asbestos reinforced plastics for rockets and missiles

heat resistant phenolics—laminated or molded, withstand direct rocket blast

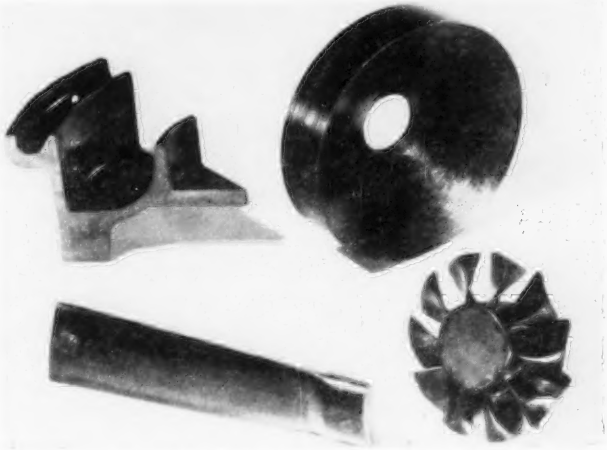
by **D. V. Rosato**, Product Manager and Chief Engineer, Raybestos-Manhattan Reinforced Plastics Department

The efficiency of a missile is related to its operating temperature; the upper limit of which is related to the heat energy producing values of the fuel, the heat absorbing qualities of the vehicle, and the heat erosion properties of the missile components. Finding existing and new, inexpensive materials capable of withstanding the temperatures of the missile environment is a problem of ever-increasing magnitude for the materials engineers.

Rapid developments in the plastics industry in the past few years, have made available to missile developers a family of low cost structural materials referred to as reinforced plastics. One group in this family, namely asbestos base reinforced plastics, is aiding engineers in solving some of the high temperature aerodynamic problems in missilry. Molded and laminated parts have served as insulation caps, blast tubes, insulation shields, rocket throat shields, flame traps, gaskets, nose cones, and accessory turbine wheels.

High strength-to-weight ratio, high modulus of elasticity at room and elevated temperatures, good heat resistance, light weight, and dimensional stability are some of the properties obtainable from asbestos reinforced plastics parts.

Rocket insulation throat and grain seat from a solid propellant powered IRBM, attest to the heat resistant properties of asbestos reinforced plastics. Similar parts are also used on smaller missiles.



Versatility of application for these plastics is shown above (clockwise): pie section of an aircraft brake drum, molded aft insulator for ICBM, missile turbine wheel which operates at 350°F, turbojet compressor blade operating to 700°F.

TABLE I

Standard Pyrotex Felts

Property	Style 40-RPD	Style 60-RPD
Thickness (based on height of 10 plies), inches ±10%	0.010	0.010
Weight per 100 sq ft, lbs (±5%)	2.0	1.8
A. S. T. M. Grade (D375-52)	AAAA	Und.
Asbestos fiber, % min.	99	80
Organic content, % max.	1	20

TABLE II

Thickness vs. Strength—Pyrotex Felt Style 41-RPD Laminate

(40 RPD Felt with Phenolic Resin)

PROPERTY	LAMINATE THICKNESS, INCH	PRESS TIME, MINUTES	NOT POST CURED		POST CURED	
			STRENGTH	E × 10^{-6}	STRENGTH	E × 10^{-6}
Flexural, psi	1/32	10	62,500	5.5	96,000	5.6
	1/32	5	50,200	4.7	90,200	5.5
	1/16	10	51,900	5.5	75,400	5.7
	1/16	5	51,000	6.0	79,300	6.0
	1/8	20	47,500	5.5	69,900	6.0
	1/8	10	46,700	5.4	68,500	5.8
	1/8	5	33,200	4.3	68,500	5.5
	1/4	50	46,800	4.3	59,900	4.7
	1/4	20	46,400	4.0	60,900	4.2
Tensile, psi	1/32	10	48,300	3.7	63,300	4.9
	1/32	5	40,600	4.4	58,200	5.2
	1/16	10	43,400	4.9	50,800	5.5
	1/16	5	33,800	4.2	61,300	6.4
	1/8	20	48,400	5.3	57,400	5.6
	1/8	10	47,700	4.9	54,000	5.2
	1/8	5	30,000	4.8	56,700	5.6
	1/4	50	52,000	5.2	56,100	5.4
	1/4	20	47,900	4.6	58,300	5.5
	1/2	60	52,000			
	1/2	20	40,000			

Notes: Parallel layup; longitudinal data; press cure 400 psi and 300° F, post cure 24 hr/300° F, 24/350, 24/400.

Feature continued on next page

asbestos reinforced plastics for missiles

Data compiled from tests conducted between 500-6000° F indicates that short time thermal insulation from high temperature rocket blasts may be expected without serious loss of strength.

The fact that high grade asbestos fibers (Chrysotile) can be subjected to temperatures above 2500° F without complete decomposition or melting, assists parts made from heat resistant resins and asbestos to retain a good portion of their strength at elevated temperatures. Asbestos phenolic laminates have been subjected to temperatures as high as 5000° F for a few seconds without complete loss of mechanical properties. Proper choice of asbestos fiber, resin, and resin cure cycle are important to obtaining optimum high temperature results.

RPD Asbestos Specifically for Missiles

Raybestos-Manhattan, Inc., has developed a family of reinforced plastic parts and raw materials named RPD, specifically for use in rockets, missiles, and aircraft. Titan, Vanguard, Polaris, Sidewinder, and Terrier missiles use laminated or molded asbestos heat insulation shields, tubing, and heat diverters. The raw materials used in producing these parts are Pyrotex sheets or felts and various molding compounds. These new raw materials can be used by any plastic fabricator to produce high-strength heat-resistant parts to the missile manufacturers' specifications. Standard molds, presses, release agents, and cure cycles are adequate. A specialty use of the Pyrotex felts has been to use them in a filament winding process to increase heat resistance, strength, and to produce non-porous structures. Heat resistant phenolic and silicone prepreg felts can be "cured in place" in metal rocket tubes to provide thermal insulation and a flame erosion medium.

The basic felts are composed of mechanically opened asbestos fibers which have been arranged in a tenuous web by carding, a step in the manufacture of most asbestos and cotton textiles. Spinning grades of asbestos ranging from No. 1 crude to No. 3R are used.

Asbestos plastic sheets are currently manufactured in several standard specifications but wide variations are possible for individual applications. The two basic felts being used in the reinforced plastics industry are identified as Style 40-RPD (formerly 9526 RB5) and Style 60-RPD.

Table I lists the properties of these felts. The ability of the felts to wet satisfactorily with resins and maintain a high wet strength is evidenced by the fact that they can be used in a continuous lamination process and run through vertical drying towers when manufacturing prepreg sheets.

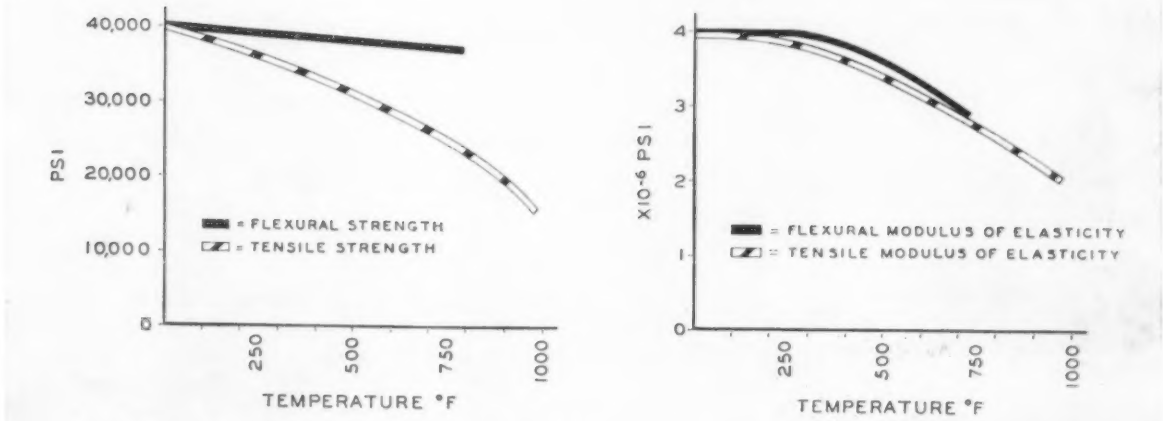


Fig. 1: The test methods used in obtaining this data were in accordance with ASTM and Federal Specification L-P-406b. Layups were isotropic (i.e.), multi-ply with maximum strength members 90 deg to each other in the same plane.

Phenolic Asbestos Laminates

The two standard felts are available impregnated with phenolic, epoxy, silicone, and polyester resins from many commercial treaters. Raybestos prepreg styles 41-RPD and 62-RPD identify respectively felts 40-RPD and 60-RPD impregnated with heat resistant phenolic resin. The resin content and flow requirements may be pre-specified to make the material adaptable to vacuum or high pressure curing (0-5000 psi). For certain curing conditions, optimum physical properties are obtained with fixed resin and flow characteristics. Style 41-RPD, for example, when cured at 400-500 psi has an optimum resin content of 25-35 per cent by weight and a flow of three to six per cent. The physical data given in Tables II, III, and Fig. 1 are based on this type of laminate. Compliance with recommended curing cycles is important since flexural strength can be reduced nearly 42 per cent below maximum and tensile strength reduced nearly 30 per cent where post cure is not used (Table II).

The strength retention data in Table III represents maximum expectant values obtained by varying post-cure time and temperature cycles from one to five days and from 250-500° F. Post-curing time and temperature are usually governed by the thickness and shape of the part. When blistering or delamination occurs in the post-cure, increased curing time at lower temperatures is recommended. Post-curing need not be conducted under pressure. In instances where the curing cycle is extended, where finished parts are to be exposed to temperatures of 300° F, or where maximum strength is not a criteria, post curing is not recommended.

The physical properties of laminates are largely dependent on the type of mold used, the molding pressure, and the asbestos-resin ratio. The flow characteristics of the resin should coincide with molding and laminating techniques and pressures.

Another raw material available to fabricators of plastic parts is the Pyrotex mat preimpregnated with phenolic resin. Prepreg mats can be made in any weight up to 10 ounces per square foot; standard weights being 2½, 5, and 10 ounces per square foot. When pressed at 400 psi the thicknesses are 1/64, 1/32, and 1/16 in. respectively.

Molding Compounds

RPD molding compounds are basically asbestos base with various combinations of fillers and binders; such as, glass, ceramic, metallic oxides, phenolic, silicone, etc. The more conventional types are asbestos-phenolic and are identified as Styles 110-RPD, 150-RPD, and 160-RPD. The silicone compound is identified as Style 310-RPD. Style 390-RPD is asbestos-Teflon which yields high compression values (15,000 psi) compared to unfilled Teflon (1000 psi).

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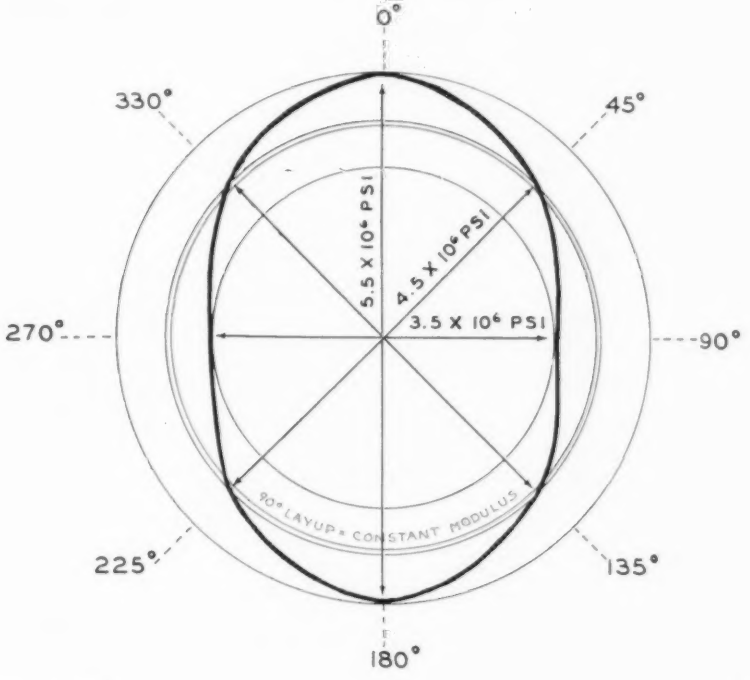


DIRECTIONAL STRENGTH PROPERTIES

Modulus of Elasticity

In parallel layups, using a typical asbestos-phenolic laminate, the physical properties are in the ratio of approximately 3:2 when going from longitudinal to transversal direction, the longitudinal direction being the machine or length direction of individual fibers The layup of individual plies can be oriented in various patterns to produce laminates having varying physical properties. The colored line above shows the isotropic properties of a laminate made by laying two individual plies 90 deg to each other.

asbestos reinforced plastics for missiles

These compounds are specifically adapted for compression or transfer moldings. The molding compounds are not structurally as strong as the sheet materials (41-RPD), but can meet most thermal erosion or thermal conductivity requirements.

Post Curing and Machining

To develop maximum strength and dimensional stability, molded parts also should be post cured. Time and temperature for post curing depend on the thickness and shape of the part. If blisters or delamination occur during post cure, increase curing time at lower temperatures.

Molded parts are usually shaped to final dimensions by a light machining using standard metal finishing machines and cutters. Machinability is good. Individual parts are joined in a number of ways, adhesive bonding being the most common. The bonding characteristics of the individual resins vary, silicone and Teflon being two of the more difficult resins to bond.

Aerodynamic Heating Tests

Parts have been tested in actual and simulated aerodynamic heating conditions to follow load-temperature-time cycles of varied missile components. Oblation rates of .0052 to .0072 in./sec were observed on flat inclined test panels exposed to burning propellant temperatures of 4700° F at Mach 2.5. Parts have been made to withstand the full burning time of missile propellants. In one prototype missile, a grid molded structure was repeatedly exposed to direct contact of the propellant heat at speeds over Mach 1.

THERMAL PROPERTIES
MOLDED 41-RPD SHAPES

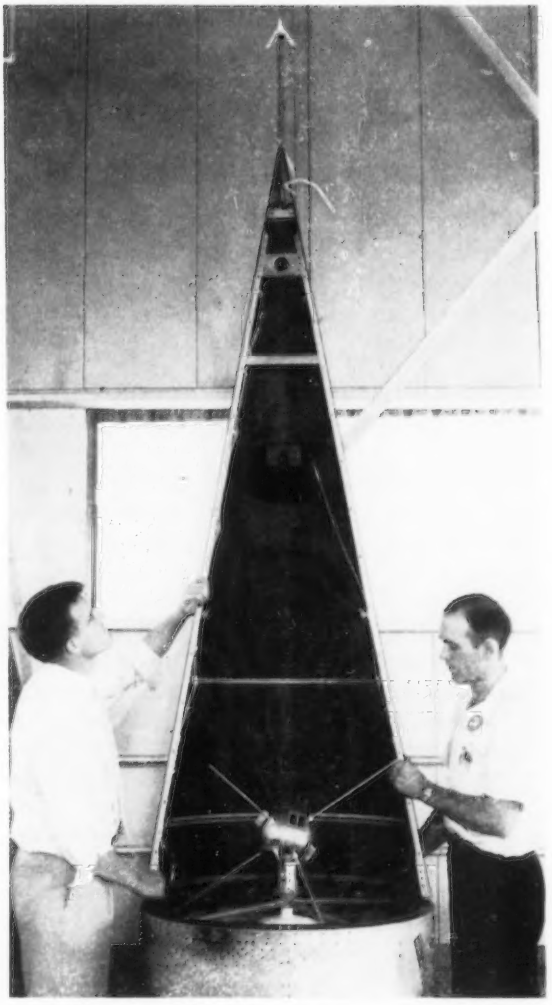
Specific heat (Room Temperature)

$C_p = 0.308$ BTU/lb/° F

Thermal Conductivity

Mean Temp., ° F	K-BTU/hr/sq ft ° F/in.
100	0.87
200	1.02
300	1.18
400	1.33
500	1.49

Coefficient of expansion (Room Temperature to 600° F)
2 to 4 x 10⁻⁶/° F.



Clam shell nose cone which protects Vanguard test satellite is of asbestos reinforced plastic.

Surfacing with Asbestos Felts

The results of a WADC technical report recently made available show that heat resistant glass reinforced polyester laminates, with low water absorption and good retention of mechanical properties without crazing or cracking on exposure to temperatures at 500° F for extended periods, can be made by overlaying a .010 in. thick asbestos coating. No cracks were observed after 200 hours at 500° F.

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TABLE III

Properties of Pyrotex-Phenolic Resin Laminates*

Property	R/M Styles 41-RPD felt 42-RPD mat	R/M Style 61-RPD felt
Resin Content, weight	25-30%	25-30%
Press-cure cycle (⅛-in. laminate):		
Pressure	400 psi	400 psi
Temperature	300° F	300° F
Time	30 min	30 min
Post-cure cycle, hr/°F.	4/300 8/350 8/400	4/300 8/350 8/400
Specific gravity	1.8	1.8
Properties at room temp.:		
Flexural modulus of elasticity	5.0-6.0 x 10^6 psi	2.8 x 10^6 psi
Ultimate flexural strength	50,000-55,000 psi	35,000 psi
Tensile modulus of elasticity	5.0-6.0 x 10^6 psi	3.5 x 10^6 psi
Ultimate tensile strength	45,000-55,000 psi	24,000 psi
% Retention of properties after 30 day immersion in water:		
Flexural modulus	90-100	90-100
Ultimate flexural strength	90-100	90-100
Ultimate tensile strength	80-100	90-100
At 300° F after 200 hr at 300° F:		
Ultimate flexural strength	85-90	
Flexural modulus	85-90	
At 500° F after 100 hr at 500° F:		
Ultimate flexural strength	68-78	
Flexural modulus	80-90	
At 500° F after 200 hr at 500° F:		
Ultimate flexural strength	52-60	
Flexural modulus	68-75	
At 700° F after 5 hr at 700° F:		
Ultimate flexural strength	45-50	
Flexural modulus	48-52	
At 1000° F after ½-hr at 1000° F:		
Ultimate tensile strength	20-25	
Tensile modulus	35-38	

* Longitudinal test data on parallel layup.

•WHAT ASBESTOS IS

Asbestos is the name given a number of fibrous mineral silicates of varying chemical composition. A feature peculiar to each silicate is that the crystals which comprise it are extremely long in relation to their thickness. This characteristic is generally accepted as giving asbestos higher mechanical properties than other fibers.

Chrysotile, found in veins in the base serpentine rock, is superior to all asbestos varieties. All fibers of Chrysotile asbestos are of the same diameter. The molecular formula of the substance is $Mg_6Si_4O_{11}(OH)_6 \cdot H_2O$, indicating it is a hydrated silicate. The Si_4O_{11} chains run the length of the fiber, each Si atom being enclosed by a tetrahedon of four oxygen atoms so disposed that two oxygen atoms are shared by adjacent tetraheda to form an endless chain. The magnesium and hydroxyl groups serve as lateral connectors.

When the crystal orientation is good, the fibers are long, soft and silky, are of constant diameter, and exhibit high mechanical properties.

When orientation of the crystals is such that the Si_4O_{11} chains are not parallel to the longitudinal axis of the fiber, the strands are harsh and of uneven dimension.

Properties of Chrysotile fibers

Modulus of elasticity	20-25 x 10^6 psi
Tensile strength	80-200 x 10^3 psi
Specific gravity	2.5
Color range	green, grey, amber to white
Fusion point	2770° F

bearing temperature 600°F
where would you turn for a lubricant?

silicones for mach 2+

by **John Kushnerick,** Materials Editor

Temperature requirements for materials in design of aircraft and missiles continue their upward spiral, taxing materials engineers to the limit of their knowledge. The areas we usually think of when high temperature materials are mentioned are missile nose cones and air-foil leading edges. This is because our journals have given metals for these areas the more spectacular play; they are the areas where immediate problems exist. The problems will by no means stop here. Prolonged operation in our own atmosphere at high Mach numbers may extend high temperature requirements to materials in virtually every part of the airframe and powerplant. Engineers investigating high temperature lubricants and hydraulic fluids believe they have managed to stay one step ahead of the designers' demands with a new family of silicones.

Capable of intermittent operation up to 700°F, a new family of silicone fluids with additives has been introduced by the General Electric Co. The fluids show improved lubricity and anti-oxidation properties while retaining the excellent low volatility and low viscosity-temperature coefficients characteristic of other silicones.

Complete oxidation stability up to 510° F has been achieved in the lubricating silicones by incorporating an anti-oxidant additive to an existing silicone polymer known commercially as Versilube F-50. Lubricity, a measure of a lubricant's ability to support a load (the inherent weakness of most silicones) has been improved by introducing extreme pressure molecules, in this case chlorophenyl groups, tin, and an undisclosed polymeric additive.

High temperature operation is so demanding that no existing lubricant holds a marked superiority at the extreme temperature operations anticipated in Mach 2+ aircraft, for all of the six basic requirements commonly desired of a lubricating fluid (lubricity, oxidative stability, thermal stability, low viscosity temperature coefficient, anti-corrosion, and hydrolytic stability). The improved silicones, however, present a good balance, and are available as specialized fluids where either lubricity or oxidative and thermal stability might be the primary dictate of design.

Fluid 81644 is intended for lubricating systems where resistance to oxidation is the primary requisite. Fluid 81717, although it possesses good lubricity, is intended for use in hydraulic systems, where thermal stability and lubricity are the prime requisites. The older F-50 fluid is a non-additive lubricant which has the best thermal stability of the three.

High Temperature Stability

Degradation reactions at high temperatures are placed in two groups: those involving oxidation and those resulting from extreme temperatures with most lubricants. The new silicones require an activation temperature of about 600°F before any rearrangement of the molecule occurs. Above this temperature, degradation increases proportionally with temperatures. The vapor pressure chart shows the point where degradation begins, as evidenced by the sharp break in the curve. The slightly higher vapor pressures of 81717 and 81644 are due to the tin and anti-oxidant additives respectively.

The rate of breakdown is dependent on temperature. At 700°F the rate is about four per cent per hour; F-50 being slightly less.

Breakdown products are low weight, non-abrasive, non-toxic, and non-corrosive volatile triamers. No chemical means is known to inhibit degradation, but under pressure (i.e., as in a hydraulic system of 1500 psi capacity) a chemical reversal occurs in which breakdown products revert to the original silicone. Oxidative stability

is evaluated by considering five individual properties: minimum temperatures of oxidation, rate of oxidation, oxygen tolerance, oxidation corrosion, and coking.

Minimum temperature of oxidation for the silicones (threshold temperature) is high in comparison with conventional lubricants: 510°F for 81644 fluid and 450°F for 81717 fluid. Rate of oxidation and oxygen tolerance are low in comparison with conventional lubricants: one gram of oxygen per five grams of lubricant per hour at 500°F. The silicones are non-corrosive to most metals even at extreme temperatures. Copper, however, is attacked at temperatures above 450°F.

The most notable characteristic of high temperature oxidation is that viscosity of the oil increases with temperatures and amount of oxygen in the atmosphere. This is because of the molecular rearrangement which occurs, releasing formaldehyde and increasing the molecular weight of the resultant polymer. Extreme oxidative conditions would produce a solid gel. Conventional lubricants form acids, coke, tar, water, and some insolubles as their oxidation breakdown products.

Oxidation may be inhibited by blanketing the silicone liquids with an inert atmosphere, as encountered at high altitudes. When the oxygen content of the air is below nine per cent at 500°F, oxidation is undetectable by normal test methods. At 700°F in an atmosphere of five per cent oxygen, breakdown is similar to thermal degradation because a volatile triamer is formed.

Lubricity

The first improvement to silicone lubricants was made on a laboratory scale several years ago by introducing chlorophenyl groups into the polymeric chain. This resulted in the fluid known commercially as F-50.

Load carrying ability has been increased in the 81717 fluid by incorporating a tin additive. General lubricity and oxidation properties have been improved simultaneously by the anti-oxidant polymer.

The results of Shell Four Ball Wear Test are shown in Table I. The superior load carrying ability of 81717 is apparent. The diester lubricants, which have high load carrying ability in the temperature ranges indicated, are markedly lower at 700°F, and also have unsuitable high temperature oxidation properties.

Continued on next page

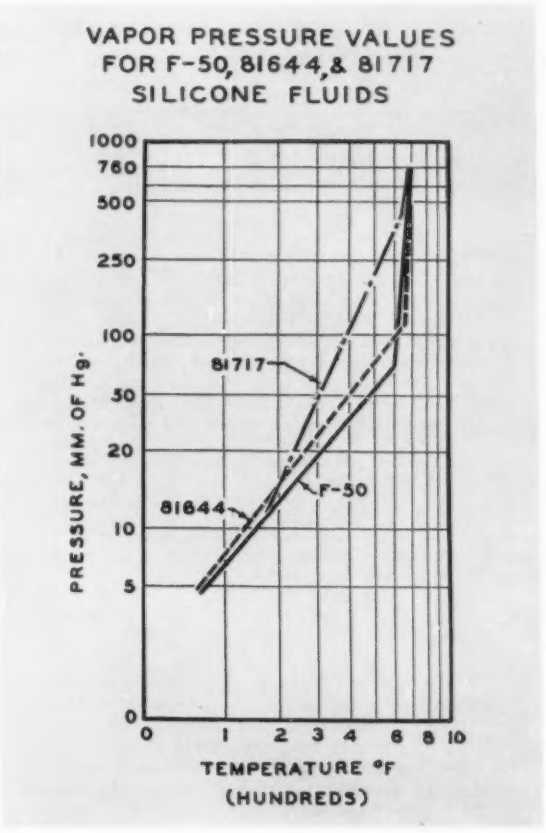
TABLE I

Shell Four Ball Tester Data

Fluids	*212° F*	*400° F*
81644	45 Kg	38 Kg
81717	90 Kg	60 Kg
Versilube F-50	40 Kg	30 Kg
Diester	130 Kg	100 Kg
Petroleum	70 Kg	50 Kg
SF-96 (methyl silicone)	20 Kg	15 Kg
20% phenyl silicone	5 Kg	1 Kg

Viscosity Temperature Data

Temperature °F	*81717 Centistokes*	*81644 Centistokes*
—65	3187.0	2848.0
—30	846.0	705.0
0	390.0	310.0
100	71.3	65.6
210	22.0	22.0
300	12.9	13.0
450	5.5	5.2
700	1.9	2.4



Viscosity

The viscosity-temperature coefficient is a measure of viscosity change with temperature. When this is ideally zero, a lubricant would have the same viscosity at 100 and 700°F. Silicones in general demonstrate a marked superiority over other lubricants in this category. Viscosity stability is one of the three prime requisites of a good lubricant, thermal stability and lubricity being the other two.

General Properties

The silicones described above have a flash point of 560-575°F, and will ignite about 900°F. This means lubricant or hydraulic fluid would ignite by contacting a hot combustion chamber in the event of leakage. This hazard is not uncommon in conventional fluids.

Ordinary seals are not affected appreciably by the silicones in temperature ranges normally considered safe for the seals.

Skin tests have indicated that the fluids are essentially non-toxic. These tests however were run at room temperature only and are not indicative of possible vapor toxicity at elevated temperatures. Since it is known that formaldehyde is a primary product of high temperature oxidation, all precautions normally used when handling the latter should be exercised.

The direct addition of silicones into conventional lubricating and hydraulic systems is not advised. Equipment in which silicones are to be used should be cleaned; bearings should be disassembled if possible. All reservoirs, sumps, and filters should be flushed to avoid adverse effects on the silicones.

Applications and Problems

1. The silicones with additives, described herein, were developed in view of preliminary design expectancies for a now defunct ground-to-ground pilotless bomber. No aircraft or missile now in production has bearing surfaces to be lubricated at the temperature capabilities of the new silicones.

2. Bearing materials for operation at 700°F are under evaluation; M series 1, 2, 5, 10, and 50 tool steels are now being considered.

3. Seals capable of high temperature operation are in the development stage. Viton A and some asbestos base materials indicate possibilities.

4. Silicones have been used as high temperature forging die lubricants, also as cutting oils.

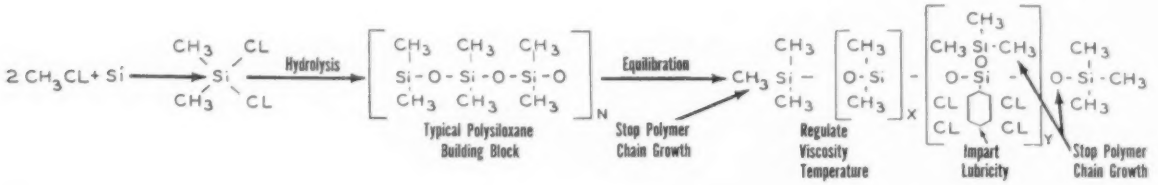
5. Silicones discussed here foam somewhat more than lubricants presently in use. At this time some anti-foam agents for silicones are under evaluation.

What Silicones Are

The term silicone is generic for all of the organopoly siloxanes now available. Their manufacture usually begins from a variety of silica bearing ores. The ore is reduced to pure silicon (Si) and then reacted with methylchloride (CH_3Cl) in the presence of a copper catalyst, to produce the first functional intermediates known as meythl chlorosilanes. Then, by a hydrolysis reaction, the basic polysiloxane group is formed. This polysiloxane molecule serves as the building block to which are attached functional groups that impart the desired properties to the end molecule.

The group which imparts lubricating properties to the basic molecule is the chlorophenyl group. The length of the organosilioxane chain regulates viscosity temperature properties, and the tri-methyl group is used as a "chain stopper" to regulate the size of the molecule.

The entire process is expressed chemically as follows:



On thermal decomposition, the polysiloxane molecule is attached at the end of the silica linkage and a cyclic triamer is formed. This compound is volatile at elevated temperatures, and is soluble in the parent polysiloxane at room temperatures under 1500 psi when the triamer chain opens and reverts to the original polymer.

On oxidative degradation, the polysiloxane, is attached in a different manner and formaldehyde is produced. An oxygen bridge is then formed between two or more molecules, resulting in an increase in molecular weight and an increase in the viscosity of the lubricant.

DESIGN

TheSeaMaster; Its Development and Some Considerations from the Accidents.

J. L. DECKER. *Aero Eng. Rev.*, (November 1957), 5 pp.

The SeaMaster is discussed in terms of its design problems and the accomplishments of its first flight tests. Also included is a report on the accidents as well as a summary of what was learned from them.

The Hot Airplane

H. B. SIPPLE and G. G. WALD. *Mech. Eng.*, (October 1957), 3 pp.

Discussion of materials and manufacturing methods as influenced by high-temperature considerations of supersonic flight.

New Tire for STOL-Type Aircraft May Permit Rough Field Landings.

V. FRISBY. *SAE*, (November 1957), 3 pp.

High tensile strength nylon is woven around a natural rubber low-pressure tire. Tires are deflated in flight for easy stowage, reinflated on landing.

STOL Aircraft Coming to the Fore in Many Countries.

R. BANNACK. *SAE*, (November 1957), 2 pp.

Brief description of STOL types and advances being made with each configuration.

Handbook of Layout and Dimensioning for Production.

H. H. KATZ. Macmillan, 1957; 479 pp. $15.00.

This book stresses practical, industry-defined layout and dimensioning requirements. Each step in product development from technical sketch to final drawing is illustrated and detailed in terms of the procedures, principles, and theory involved. Each step is related to the ultimate goal—optimally efficient mass production.

MATERIALS

Dangerous Properties of Industrial Materials.

N. I. SAX; assisted by L. Goldwater, W. B. Harris, J. B. Harley, J. J. Fitzgerald, and M. S. Dunn, Reinhold, 1957, 1467 pp. $22.50.

A successor to Sax's *Handbook of Dangerous Materials*, it is an entirely rewritten and expanded version of the original work which was a convenient reference volume on the hazardous properties of chemical compounds and other industrial materials to enable chemists, engineers or nontechnical personnel to find quickly whether a given compound or material is potentially dangerous and what precautionary measures must be taken.

PRODUCTION

How to Determine Production Tolerances — Part Two: Statistical Methods and Selective Assembly.

KARL H. MOLTRECHT and ROBERT M. CADDELL. *Tool Engr.*, (November 1957), 5 pp.

Practical application of statistical techniques to develop tolerances of individual components which will be assembled into a complete unit.

Industry Uses Radioactivity.

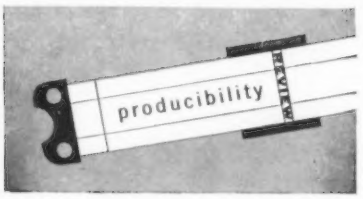
SAE, (November 1957), 2 pp.

Five ways in which industry is putting the radioactive isotopes to use.

Continued on next page

REVIEWED IN THIS ISSUE

Aero. The Aeroplane (British)
Aero. Eng. Rev. Aeronautical Engineering Review
Acft. Prod. Aircraft Production (British)
Amer. Mach. American Machinist
Amer. Tech. American Technical Society
Elec. Ind. Electronic Industries and Tele-Tech
Eng. Aeronautical Engineering (British)
Harvard The Harvard University Press
Mach. Machinery
Macmillan The Macmillan Co.
Mech. Eng. Mechanical Engineering Review
Prod. Eng. Product Engineering
Reinhold Reinhold Publishing Corp.
Ronald Ronald Press Co.
SAE SAE Journal
Steel Steel, Penton Publishing Co.
Tool Engr. The Tool Engineer
WADC Wright Air Development Center



Production-Proved Numerical Control: 3 Steps from Print to Part.

HARRY E. ANKENEY and D. H. BINGHAM, JR. *Amer. Mach.*, (November 4, 1957), 12 pp.
Applications of numerically controlled contouring equipment.

Electrolytic Grinding Pays Its Way in Just One Day.

EVERETT W. DENISON and CARL V. RUEHRWEIN. *Mach.*, (September 1957), 2 pp.
Specific application to removal of fine surface cracks from jet turbine buckets.

Job-Shop; Tracer-Controlled Machining and the American Subcontractor.

JAMES DILLON. *Acft. Prod.*, (November 1957), 4 pp.
Discussion of methods, materials, and applications of contour-machining and integral-stiffening.

Ultrasonics — The New Electronic Art (Part 1.)

J. E. HICKEY, JR. *Elec. Ind.*, (November 1957), 6 pp.
How the new ultrasonic devices work and some of their present applications.

Barrel Finishing Operation Improves Fatigue Strength of Jet Engine Part.

J. D. MARBLE and C. V. RUEHRWEIN. *Tool Engr.*, (November 1957), 3 pp.

Cutting Material and Machining Costs with Power Roll Forming.

E. W. BARTLE. *Tool Engr.*, (November 1957), 4 pp.
Description of specific applications of power roll forming as used at Orenda Engines Ltd.

Glasscloth Dies for Small-Quantity Production by the Swedish Fluid-Form Process

Acft. Prod., (November 1957), 2 pp.
Experimental and short-run production of airframes and gas-turbines.

How to Determine Production Tolerances — Part One: Complete Interchangeability.

KARL H. MOLTRECHT and ROBERT M. CADDELL. *Tool Engr.*, (October 1957), 4 pp.

High-Speed Methods Weld to Aircraft "Specs."

GORDON PARKS. *Amer. Mach.*, (October 21, 1957), 4 pp.
Special, automatic welding equipment for joining aircraft parts at Solar Aircraft Co.

Rotor-Disc Comparator; A New Instrument for Measuring Automatically the Pitch Errors of the Fir-Tree Form Blade-Root Serrations.

L. W. NICKOLS. *Acft. Prod.*, (November 1957), 5 pp.
Detail description of system and its operation.

Pressing Makes Better Aircraft Forgings.

Amer. Mach., (October 21, 1957), 2 pp.
No-draft forging effected by slow-acting hydraulic press conveys accurate impression.

Automation in Practice.

S. E. RUSINOFF. *Amer. Tech.*, 1957; 261 pp. $6.50.
A practical work devoted to automation. It brings together the methods and machinery of automated production in the metal industries. Beginning with a discussion of basic principles such as self-regulation, negative feedback, the theory of closed loop, control systems, etc., it proceeds to the application of these principles in the major types of control devices used in today's automated and semi-automated plant. Following are chapters devoted to the use of automatic equipment in almost every area of metal production.

GENERAL

200 Miles Up, The Conquest of the Upper Air. Second Edition.

J. G. VAETH. Ronald, 1957, 261 pp. $5.00.
This is the story of the highest flights yet achieved or about to be achieved, by man-made objects. Its characters are the immensely powerful rockets, the high soaring balloons, and man-made satellites; its theme scientific research; its setting the frontiers of space; and its time the present and the future.

Guided Weapons.

E. GURGESS. Macmillan, 1956, 255 pp. $5.00.
A reference book which classifies each type of missile according to its use: ground-to-air, air-launched, and ground-to-ground missiles. Each category is treated in a separate chapter, discussing specific information on guidance system, power plant propellant, and lethal effectiveness. Also included is the dramatic story of missile development during World War II.

Guided Missiles in War and Peace.

N. A. PARSON, JR. Harvard, 1956, 161 pp. $3.50.
Here, in brief compass, is an easily understandable introduction to guided missiles; explaining why they are needed, how they have come into being, how they fly, how they are guided, and how they are powered. A historical background is given, as well as a forecast of missile influence on air, naval, and land combat operations. Peacetime potentialities of missiles are also outlined.

materials / components

360-Channel VHF Radio Weighs Only 22 Pounds

A vhf communications system weighing only 22 pounds is now in production.

The system provides a frequency coverage of 118 to 135.95 mc on 360 channels, and

is suitable for both military and commercial aircraft. It is designated ARC Model 210.

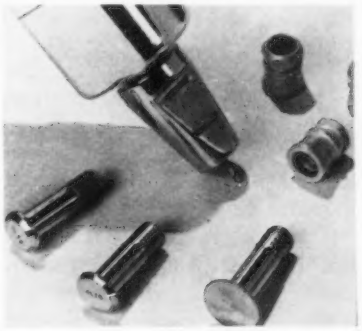
The system is powered by a dynamotor designed to give maximum dependability with the least possible weight. An advanced type of center-of-gravity mount reduces vibration and noise effects below the levels usually found in this type of equipment.

Aircraft Radio Corp.

Circle 121 on postcard for more data

Fastener Has Built-In Torque-Control Device

A positively controlled preload fastener with a torque-off collar is shown below. It is named Hi-Lok.



The fastener is conventionally installed with a small power tool, but has provisions for hand installation by an Allen, open end, or ratchet wrench.

It is available in a wide variety of materials.

Hi Shear Rivet Co.

Circle 122 on postcard for more data

Chemical Composition of PH 15-7 Mo Stainless

Armco PH 15-7 Mo is a new and higher strength precipitation hardening stainless steel possessing an outstanding combination of room temperature and elevated temperature mechanical properties. It is readily fabricated in the annealed condition. It can be hardened by low temperature heat treatments with minimum distortion and exhibits good corrosion resistance.

The material is similar in composition and structure to Armco 17-7 PH. Molybdenum is added to the new stainless steel to increase its mechanical properties at temperatures up to 1000°F.

The chemical analysis is maintained in approximately the same balance as in 17-7PH in order to provide similar transforming and hardening characteristics during heat treatment.

The analysis of PH 15-7 Mo is as follows:

Element	*Percentage*
Carbon	.09 max
Manganese	1.00 max
Phosphorus	.04 max
Sulfur	.04 max
Silicon	1.00 max
Chromium	14.00 to 16.00
Nickel	6.50 to 7.75
Molybdenum	2.00 to 3.00
Aluminum	.75 to 1.50

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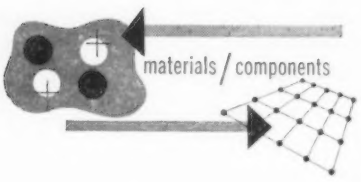


The new stainless is supplied in a wide range of sizes in sheet, strip, plate, bar, and wire forms. These products are delivered to the user in the annealed condition, designated as Condition A, ready for fabrication. Sheet and strip are also produced in a hard-rolled condition designated as Condition C for applications requiring maximum strength.

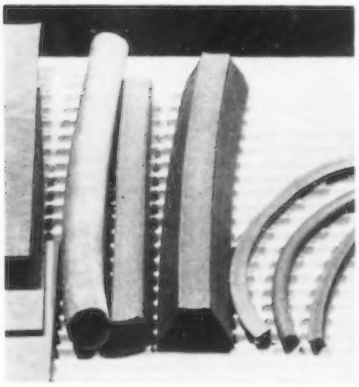
Armco Steel Corp.

Circle 123 on postcard for more data

Close Tolerances Held By Silicone Sponges

Two new silicone compounds make possible the production of sponge rubber components to close tolerances. Designed SE-546 and SE-547, these compounds are usable from —120 to +500°F.

SE-546 meets requirements of AMS 3196 for firm; SE-547, AMS 3195 for medium.



Both compounds form uniform, unicellular sponge with good compression set and vibration damping properties. Shapes can be extruded for free or mold expansion, or molded and cured in a single operation.

General Electric

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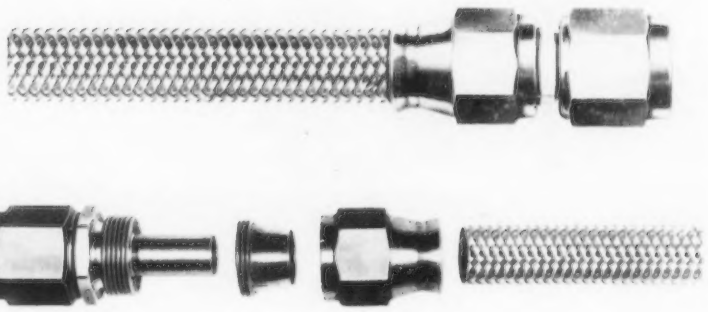
Triple Lock Hose Fitting Safe, Yet Easy to Maintain



Seal-Lock, a triple locking, reusable fitting for use with high temperature Teflon hose, has recently been made available for units which require field service.

The fittings are not easily loosened by vibration. They can be inspected readily before completing the assembly. Blow-offs do occur on a correctly installed fitting.

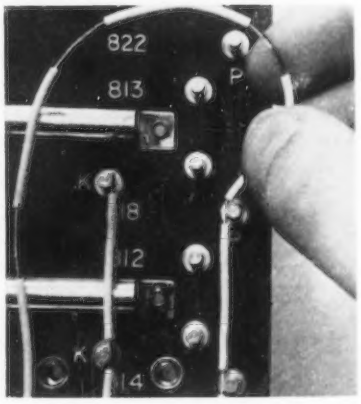
Two built-in seals are dynamically actuated by internal pressure to preclude leaks. Left hand assembly threads prevent accidental loosening during installation. The flared skirt on the socket makes assembly easy yet protects the hose from concentrated stresses. Critical parts are hardened to provide the extra safety factor for removing and reinstalling the fittings without damage.

Seal-Lock fittings are assembled in the field without the use of special tools or special skills.

Resistoflex Corp.

Circle 126 on postcard for more data

Interval Stripping of Wire Possible with New Device



Centerstripping equipment has been developed which removes the insulation from stranded or solid conductors of any gauge.

The stripped portion may be specified to any length above $\frac{1}{8}$ in. and may be located at either regular or irregular intervals throughout the length of the wire.

Centerstripping is of particular interest to manufacturers of products where multiple banks of electrical components have common terminating points. One continuous centerstripped wire can be used in place of two or more single leads. This results in neater, faster assembly, improved connections, and lower installation costs.

Manger Electric Co.

Circle 125 on postcard for more data

Air Duct Joints Are Self-Aligning

Production of a new line of high temperature (550°F) self-aligning air-duct joints for the aircraft, missile, and related industries has been announced. The new air-duct joints

have longer cycle life with 10 deg self alignment and 360 deg rotation.

The Self-Aligning Air-Duct Joints are available in a bore size of 5 in. with operating pressures of 110 psi and a temperature operation of 550 F. Other bore sizes can be made on request.

Southwest Products Co.

Circle 127 on postcard for more data

Switch Remotely Adjustable Without A Servo System

A new concept in automatically calibrating and setting a pressure switch from a remote position has been announced with introduction of the Electroset pressure switch. The switch operates under atmospheric environments from 0 to 15 psi with accuracy of 2mm Hg.

In operation, one contact is engaged when the desired set

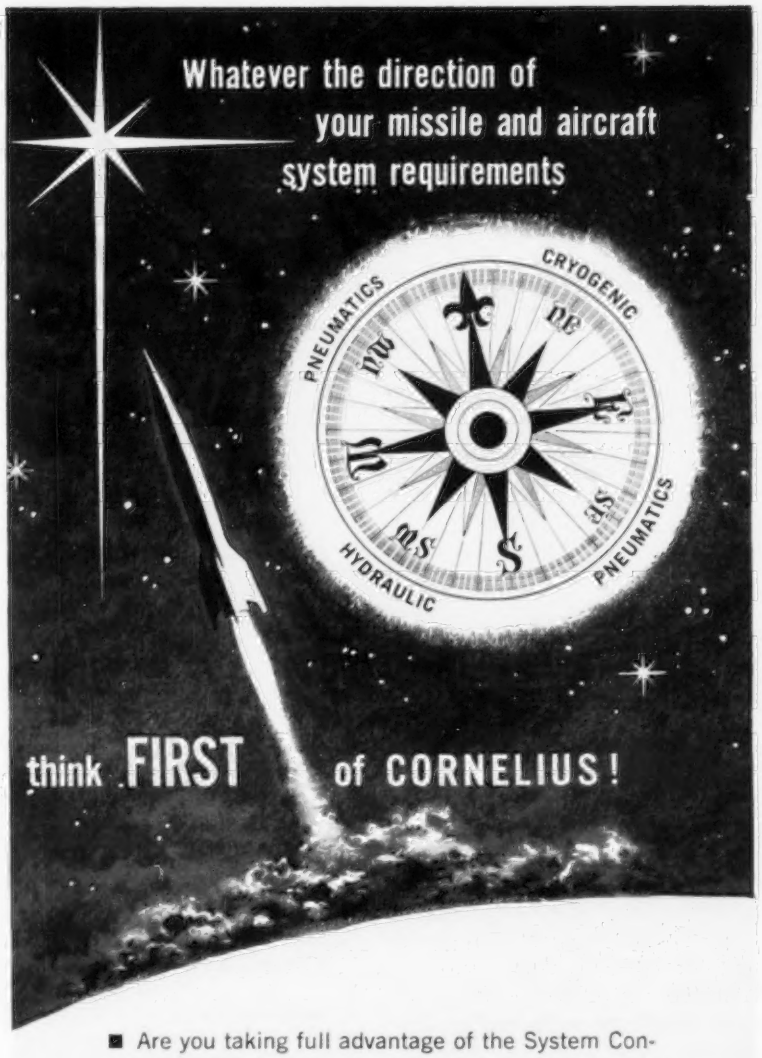
pressure is applied. The other contact is unlocked by energizing a solenoid and is locked by de-energizing the solenoid. In this set position, the switch contacts will open at pressures below the calibrating pressure and close at pressures equal to or above the calibrating pressure.

The Electroset pressure switch is vacuum-sealed, isolated from dirt, moisture, or corrosive fluids, including the fluids used to actuate it.

Trans-Sonics, Inc.

Circle 128 on postcard for more data

Continued on page 97



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worth asking for:

technical literature listed here is available without charge from the various manufacturers

Film Adhesives

Report describes Plymaster V-2 and V-3, 100 per cent reactive elastomer-phenolic film adhesives for the flat-surfase bonding of all metals and plastics. Included are technical data on new 4 and 11-mill films, and information on reactivation methods to achieve strengths over 1,800 psi.—Rubber & Asbestos Corp.

Circle 150 on postcard for more data

Electro-Probe Gaging

Described in a new four-page brochure are the Electro-Probe test indicator, a completely portable dimensional test instrument; and the Sure-Set, an electronic table positioning device for universal grinders.—Federal Products Corp.

Circle 151 on postcard for more data

Electronic Tester

A four-page pamphlet describes the Supertester which provides a mechanized facility for rapid production testing of complex electronic and electrical products. In the standard model, a series of 400 discrete, predetermined test steps can be made automatically on a go-no-go basis. The Supertester alarms and stops at failure of any test as well as at the end of a series. Detail specifications and accessories are listed.—California Technical Industries.

Circle 152 on postcard for more data

Shaft Couplings

Full-floating shaft couplings are announced in Bulletin 98. Typical applications include cooling tower drives; fan, pump and compressor drives; heavy engine drives; paper-mill machinery; marine drives; and high-speed blowers and compressors.—Thomas Flexible Coupling Co.

Circle 153 on postcard for more data

Hand Lift Trucks

Mechanical and Hydraulic Hand Lift Trucks are discussed in a new 16-page brochure giving descriptions, methods of operation, selection, and use.—Association of Lift Truck and Portable Elevator Manufacturers.

Circle 154 on postcard for more data

Resistance Winder

Catalog page, just released, illustrates and fully describes Model 209 Fully Automatic Continuous Resistance Winder, capable of winding wire up to 7/32 in. OD on continuous lengths of flat or round core material.—Geo. Stevens Mfg. Co., Inc.

Circle 155 on postcard for more data

Wire Products

A new folder briefly describes specialty wire products for bookbinding, packaging, textile, wire weaving and other industries. Compiled as a rapid reference guide, the folder also includes a handy wire gage table. —H. K. Porter Co., Inc.

Circle 156 on postcard for more data

Gear-Cutting and Broaching

A 24-page new catalog describes complete line of gear production equipment and broaching tools. Included are machines for gear tooth honing, sound testing, spline grinding and inspection; broach heat treatment facilities and automatic loaders are also presented. —National Broach and Machine Co.

Circle 157 on postcard for more data

Laminated Plastics

Thermosetting laminated-plastic sheets for printed-circuits and similar use are described in a new loose-leaf catalog. Technical Data sheets and Price Lists are included. Separate sheets on individual products are also available.—New England Laminates Co., Inc.

Circle 158 on postcard for more data

Etching Processes

Recently published Bulletin 90 describes Photoforming of metal parts for a variety of industrial and commercial products. Both chemical and electrolytic etching are described as

(*Continued on page 96*)

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Terminals and Connectors

63 **American Drill Bushing Co.**
Drill jig bushings

69 **American Welding & Manufacturing Co.**
Welded rings

75 **B & H Instrument Co., Inc.**
Testing instruments

73 **Cincinnati Milling Machine Co. Process Machinery Div.**
Hydrospin machine

76 **Cornelius Co.**
Pneumatic, cryogenic, and hydraulic systems

71 **Federal Products Corp.**
Precision gages

78 **Fenway Machine Co.**
Portable metal nibblers

79 **Gabb Special Products**
Gas caps

66 **Grieve-Hendry Co., Inc.**
Recirculating ovens

61 **Heald Machine Co.**
Multi-spindle boring heads

80 **Hi-Shear Rivet Tool Co.**
Titanium rivets

72 **King Fifth Wheel Co.**
Welded rings

62 **Sciaky Brothers Inc.**
Counter control welders

77 **Synchro-Start Products, Inc.**
Switch governors

65 **Technical Development Co.**
Filler caps

64 **Torrington Bearings**
Needle bearings

81 **Townsend Co. Cherry Rivet Div.**
Blind rivets

67 **United Aircraft Products, Inc.**
Sheet metal fabrication

MATERIALS & COMPONENTS

Alphabetical List of Products

125
Centerstripping equipment
Manger Electric Co.
121
Communications system, uhf
Aircraft Radio Corp.
130
Cryogenic pump for liquid nitrogen
Sundstrand-Denver
122
Fastener, pre-load
Hi-Shear Rivet Co.
126
Hose fitting, re-usable
Resistoflex Corp.
127
Joints, air duct, self-aligning
Southwest Products Co.
123
PH 15-7 Mo
Armco Steel Corporation
131
Plug, transparent inspection window
Technical Development Co.
124
Rubber components, sponge silicones
General Electric Co.
128
Switch, pressure, remotely adjustable
Trans-Sonics, Inc.
129
Valves, control, four-way
Valvair Corp.

Alphabetical List of Companies

121
Aircraft Radio Corp.
Communications system, vhf
123
Armco Steel Corp.
PH 15-7 Mo
124
General Electric Co.
Rubber components, sponge silicone
122
Hi-Shear Rivet Co.
Fastener, pre-load
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Manger Electric Co.
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Trans-Sonics, Inc.
Switch, pressure, remotely adjustable
129
Valvair Corp.
Valves, control, four-way

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YOUR NAME ..... TITLE .....

COMPANY .....

PLANT ADDRESS .....

CITY ..... ZONE ..... STATE .....

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NEW FOR PRODUCTION

Alphabetical List of Products

171
Diaphragm-type pump
The Keystone Engineering Co.

173
Drill press vise
Wilton Tool Mfg. Co., Inc.

175
Electronic gage block comparator
Sheffield Corp.

174
Hydraulic boom truck
Vanguard Engineering Co.

170
Indicator depth gage
A. G. Davis Gage & Engineering Co.

177
Optical measuring machine
J. Arthur Deakin & Son

178
Sheet metal holding device
Monogram Manufacturing Co.

172
Surface finish microscope
Engis Equipment Co.

176
Universal precision gage
Shepard & Young Tool Co.

Alphabetical List of Companies

170
A. G. Davis Gage & Engineering Co.
Indicator depth gage

177
J. Arthur Deakin & Son
Optical measuring machine

172
Engis Equipment Co.
Surface finish microscope

178
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The Keystone Engineering Co.
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Hydraulic boom truck

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Wilton Tool Mfg. Co., Inc.
Drill press vise

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YOUR NAME ..... TITLE .....

COMPANY .....

PLANT ADDRESS .....

CITY ..... ZONE ..... STATE .....

WORTH ASKING FOR

Alphabetical List of Items

150 **Adhesives, film**
Rubber & Asbestos Corp.

153 **Couplings, shaft**
Thomas Flexible Coupling Co.

168 **Fasteners, special**
Simmons Fastener Corp.

161 **Form, suggestion**
Uarco, Inc.

151 **Gaging, electro-probe**
Federal Products Corp.

157 **Gear-cutting and Broaching**
National Broach & Machine Co.

166 **Machines, milling**
Colonial Broach & Machine Co.

164 **Modulator, pulse**
Levinthal Electronic Products, Inc.

158 **Plastics, laminated**
New England Laminates Co., Inc.

159 **Processes, etching**
Superior Tube Co.

156 **Products, wire**
H. K. Porter Co., Inc.

165 **Shaker, sieve**
Soiltest Inc.

169 **Springs**
Hunter Spring Co.

163 **Switches, force control**
W. C. Dillon & Co.

160 **Switch, pressure**
Trans-Sonics, Inc.

152 **Tester, electronic**
California Technical Industries

167 **Trucks, fork-lift**
Lewis-Shepard Products, Inc.

154 **Trucks, hand lift**
Association of Lift Truck and Portable Elevator Manufacturers

155 **Winder, resistance**
Geo. Stevens Mfg. Co., Inc.

162 **Wing-Nuts**
Gries Reproducer Corp.

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Alphabetical List of Companies

154 **Association of Lift Truck and Portable Elevator Manufacturers**
Trucks, hand lift

152 **California Technical Industries**
Tester, electronic

166 **Colonial Broach & Machine Co.**
Machines, milling

163 **W. C. Dillon & Co.**
Switches, force control

151 **Federal Products Corp.**
Gaging, electro-probe

162 **Gries Reproducer Corp.**
Wing-Nuts

169 **Hunter Spring Co.**
Spring

164 **Levinthal Electronic Products, Inc.**
Modulator, pulse

167 **Lewis-Shepard Products, Inc.**
Trucks, fork-lift

157 **National Broach and Machine Co.**
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158 **New England Laminates Co., Inc.**
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156 **H. K. Porter Co., Inc.**
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150 **Rubber & Asbestos Corp.**
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168 **Simmons Fastener Corp.**
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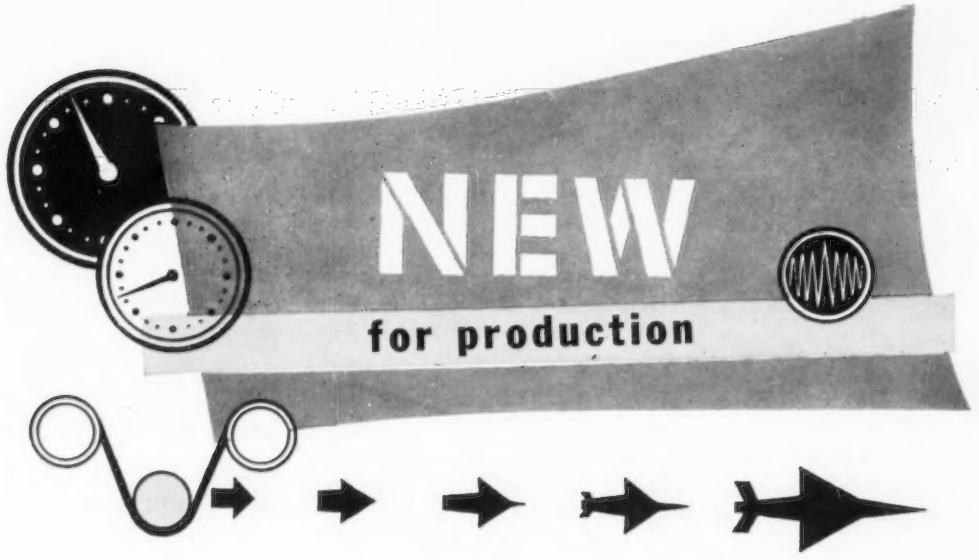
159 **Superior Tube Co.**
Processes, etching

153 **Thomas Flexible Coupling Co.**
Couplings, shaft

160 **Trans-Sonics, Inc.**
Switch, pressure

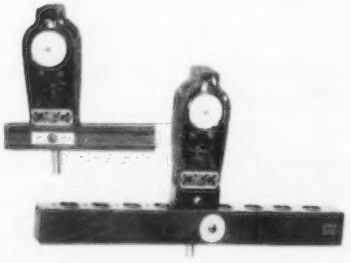
161 **Uarco Inc.**
Form, suggestion



ONE INDICATOR DEPTH GAGE MEASURES 3500 DIMENSIONS

It is now possible to select a completely standard indicator depth gage by utilizing a standard series of interchangeable gage components being marketed. By selective variation of components over 3500 standard depth gages may be specified to measure special dimensions. No alterations of these standard components are required.

Complete depth gages may be ordered by combining



the selected component model numbers which, for the most part, precludes design drawings. Where permanent record drawings are desirable or required, full-scale tracing templates are available on request. All standard models may be easily set to either gage blocks or a master set gage. Any of the popular makes of indicators can be furnished with the gage.—A. G. Davis Gage & Engineering Co.

Circle 170 on postcard for more data

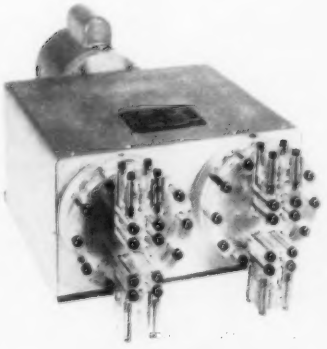
BARRIER DIAPHRAGM PUMP MOVES CORROSIVE FLUIDS

A diaphragm-type pump, specifically designed to handle corrosive fluids, is produced in both simplex and duplex models. The unit features suction lifts up to 20 ft. with standard design pressure of 50 psi. Much higher pressures, for special applications, can be obtained.

Unlike most "diaphragm" pumps, this pump is essentially a piston type. It differs from piston type pumps only in having a barrier diaphragm separating all of the working parts from the fluid handled.

All surfaces of the pump which contact corrosive media are of solid fluoro-carbons. These materials, commonly called Kel-F or Teflon, have excellent chemical resistance.

Materials other than the fluoro-carbons which may be used and are available include



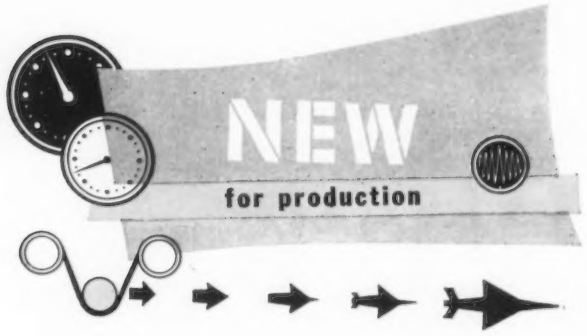
all types of stainless, Hastelloys, Rigid PVC, Uscolite, and Titanium for heads and valves; and Kel-F elastomer, Hypalon, Hycar, and Neoprene for diaphragms.

All pumps are equipped with NEMA standard type C, end-mounted motors, including explosion proof.

A variable speed electric drive can be attached to either model for controlling volumes from 1-140 gph or 5-600 gph. The pump has been used to control such process variables as flow, liquid level, pH, temperature, and others.—The Keystone Engineering Co.

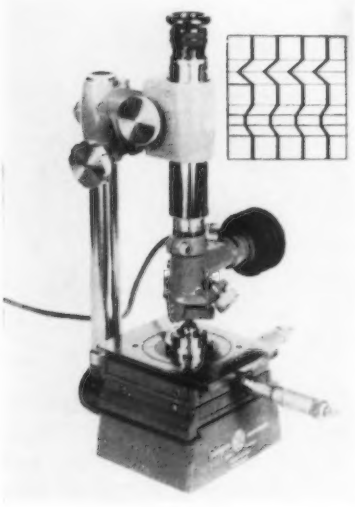
Circle 171 on postcard for more data

Continued on next page



SURFACE FINISH MICROSCOPE MEASURES SURFACE ROUGHNESS TO ONE MILLIONTH INCH

By using interference fringes, the Hilger & Watts Surface Finish Microscope permits checking of surface finish in terms of wave length of light.



With this microscope, roughness of flat or curved surfaces can be measured directly to an accuracy of .000001 in. without calculations or use of tables. The image of the surface under examination is magnified 125 times and the readings in depth are made through fringe spacing of the "contour lines." An easily adjusted camera attachment makes photographic records on 35 mm film.

The instrument is of exceptional value in checking surface finish of such products as piston rings, ball bearings, ball races, injection molds; and can be used by unskilled personnel after a few minutes' simple instruction.

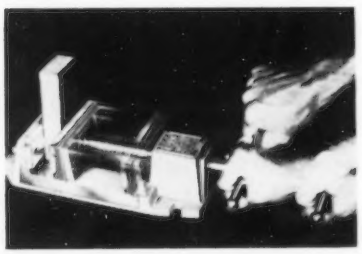
The fringe pattern described by the microscope is illustrated in the inset diagram. —Engis Equipment Co.

Circle 172 on postcard for more data

FASTER ACTION CLAIMED FOR DRILL PRESS VISE

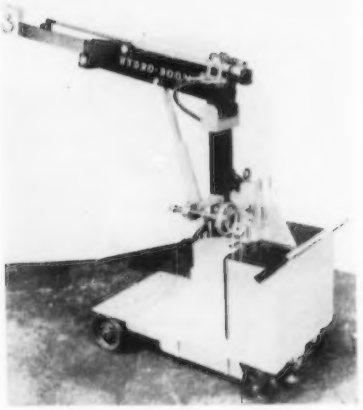
Loading and unloading times are reduced by a drill press vise which incorporates a patented Rapid Titan Nut. The nut engages and disengages the vise screw automatically. Threads are brought into contact with the screw by rotating the vise handle in the tightening direction.

The vise has a solid base and can be turned on edge for accurate 90-degree drilling. Ends of the base are cut back and the sides of the vise are machined



to form a true right angle with drill press tables. Width is 4½ in.; height, 2¾ in.; yet jaw depth is a full 1¾ in.—Wilton Tool Mfg. Co., Inc.

Circle 173 on postcard for more data



HYDRAULIC BOOM TRUCK AWARDED DESIGN PRIZE

With powered hydraulic action, the Hydro-Boom positions work loads up to 2500 lb within .01 in. First prize for design was awarded by the Society of Materials Handling and Packaging Engineers for this boom truck.

Hydraulics enable the operator of the truck, to control the telescopic boom with machine tool accuracy in vertical and longitudinal direction. A hand-operated screw gives the same precision for lateral control.

Capacity with boom retracted is 2500 lb. With the boom at full 48" beyond the front end of the truck, 1500 lb is maximum.—Vanguard Engineering Co.

Circle 174 on postcard for more data

ACCURACY TO ONE MILLIONTH OF AN INCH

One-millionth of an inch accuracy is obtained with the Eli Whitney Dualjet gage block comparator.

Measurement is amplified either 100,000 or 10,000 times by an Accutron electronic amplifier. High magnification has a .000004 in. range and scale divisions of .000001 of an inch. —Sheffield Corp.

Circle 175 on postcard for more data

Continued on next page

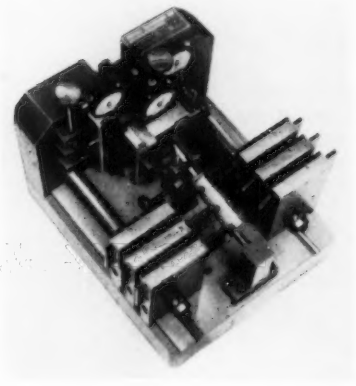
UNIVERSAL PRECISION GAGE CHECKS JET BLADE ACCURACY

A universal precision gage for checking accuracy of jet engine blades is available. The gage features airfoil template holders that are adjustably mounted on hardened and ground ways on the base of the unit. The template holders are positioned by interchangeable master gage bars. Blades of any length can be checked while maintaining template alignment accuracy of .0002 in.

The gage can be quickly changed to check different blades. This is done by changing template holders, master gage bars, template set master, and part clamping details. The template set master engages notched surfaces on the template forms, and proves the accuracy of the flush-ground ends of the forms with the template holders. Templates can be accurately reworked to compensate for wear by regrinding the air foil, setting against the set master, and regrinding the ends.

To check a blade, one is positioned in a clamping device where it is located axially from the blade mounting surfaces. The clamping device is swivel and slide-mounted to indicate both blade twist and displacement. Indicators with .0001 in. readings indicate the accuracy of the swivel and displacement measurement on the blade.

The templates engage the foil section of the blade to indicate form accuracy as well as blade tilt and bow.—Shepard & Young Tool Co.

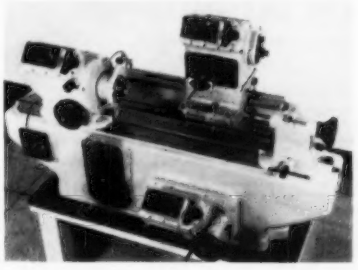


Circle 176 on postcard for more data

OPTICAL MEASURING MACHINE CHECKS 3-D CAM CONTOURS

The Alexander universal optical measuring machine for checking contours of three-dimensional cams to tolerances as close as .00005 in. is now available in the United States. This machine records rectangular coordinate dimensions and controlled rotary movements simultaneously. It is also adaptable for the checking of gears, threads, length measures, and gap gauges.

The measuring stylus is mounted on a floating ram



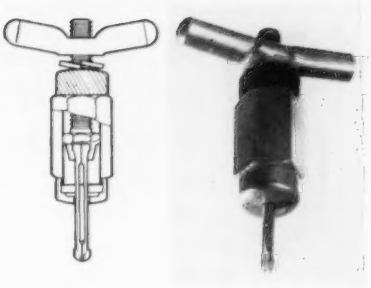
which, moving transversely, carries a glass scale marked in .05 in. divisions which are projected to vernier graduations on a screen reading to .005 in. Final readings are taken from an optical micrometer graduated to .00005 in.

Precision ball races are used on the ram and carriage.

An optical projection system, positioned on the front of the machine and similar to that of the stylus ram, provides screen readings of longitudinal increments.

The third measuring element is a standard Alexander P. G. Optical Dividing Head located in front of the ram head and parallel to the head slide. Angle of rotation may be read to 0.1 min. on a projection screen. — J. Arthur Deakin & Son.

Circle 177 on postcard for more data



SHEET METAL CLAMP NICKNAMED 'REDHEAD'

The changeover to newer, tougher, and abrasive metals in the manufacture of missiles and aircraft has created a new concept in fabricating tool design, including the essential sheet metal holding device (often miscalled "clecos").

Since first requisite was not to enlarge the size of the clamp, the basic design had to remain the same. The solution, therefore, had to be found by obtaining the ultimate strength and durability in the steel prongs, or needles, that extend through the drilled holes and tightly hold the skin to the assembly. The answer lay in producing the needles out of a specially treated specific high grade steel.

Field and laboratory tests were run to note how these needles would withstand the high tension required without damaging the locating holes or marring or scratching adjacent materials.

The clamp was then submitted to the Smith-Emery Co. for rigorous, impartial testing. Again, the clamps and its refined successors exceeded all specifications. (Smith-Emery reports are available upon request.)

One end of the clamp was marked red; therefore, was nicknamed "Redhead."

The "Redhead" will hold material to ½ in. thickness for uses in ⅛, 5/32, and 3/16 in. drilled hole sizes.—Monogram Manufacturing Co.

Circle 178 on postcard for more data

TWO ELEMENT SPEED SENSITIVE SWITCHES

The Synchro-Start Models GH-2 and GS-2 governors contain two snap action switches to be used for opening or closing circuits at any RPM over 500.

They contain sealed ball bearings, are adjustable while running and are encased in a splash proof housing. These two switch governors are supplied for the standard SAE tachometer drive or distributor take-off and for AND20005 engine pad mounting (GA Series).

Other Synchro-Start governors are available with one and three switches with a variation of mountings.

SYNCHRO-START PRODUCTS, INC.

8151 NORTH RIDGEWAY AVENUE, SKOKIE, ILLINOIS

Manufacturers of

AUTOMATIC ENGINE CONTROLS • SPECIAL CONTROL PANELS
SAFETY ALARM SETS • D.C. SOLENOIDS • HEAVY DUTY RELAYS

Circle 77 on Inquiry Card, page 81

AIRCRAFT PRODUCTION METHODS

By GORDON B. ASHMEAD

A factual tour in words and pictures of all processes in aircraft manufacture. Partial list of contents: Master plaster pattern foundry—Sheet metal forming—The drop hammer—The draw process—The Guerin process — The Verson-Wheelon process — Heat and surface treatment—Optical and assembly tooling—Plastics—Inspection, etc. 293 pages, 324 illustrations, $7.50.

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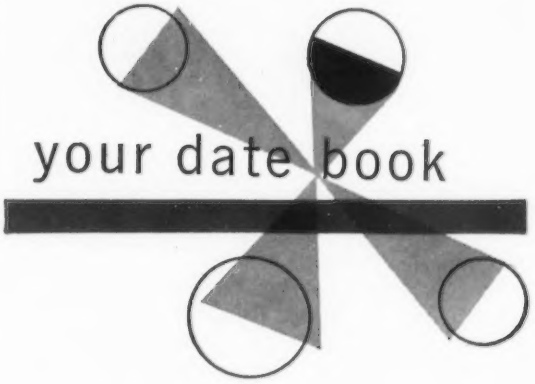


what	conference on automation
who	electronic industries association
where	arizona state college, tempe, ariz.
when	january 22-24

◆

what	annual meeting
who	institute of aeronautical sciences
where	sheraton-astor hotel, new york, n. y.
when	january 27-31

◆

what	fourteenth annual technology conference
who	society of plastics engineers, inc.
where	sheraton - cadillac hotel, detroit, mich
when	january 28-31

◆

what	fourth annual meeting
who	american astronautical society
where	new york city, n. y.
when	january 29-31

◆

what	1958 college-industry conference
who	american society for engineering
where	university of michigan, ann arbor, mich.
when	january 29-31

◆

what	thirteenth society of plastics industry conference
who	the society of the plastics industry, inc.
where	edgewater beach hotel, chicago, ill.
when	February 4-6

◆

what	committee week
who	american society for testing materials
where	hotel statler, st. louis, mo.
when	february 10-14

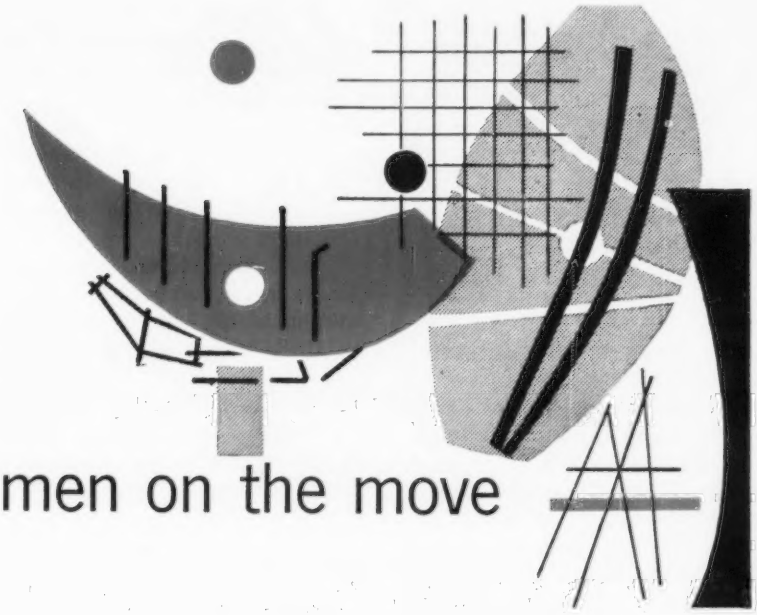
◆

what	nuclear engineering and science conference
who	institute of radio engineers, american society of mechanical engineers
where	chicago, ill.
when	march 16-21

WILLIAM PATTERSON, JR.
Vickers

GERALD M. HENRIKSEN
Acoustica Associates

ZEKE R. SMITH
Potter & Brumfield



men on the move

WILLIAM PATTERSON, JR., formerly manager of engine applications sales, has been promoted to a newly created position in the Aero Hydraulics Division of Vickers, Inc. He is now Preliminary Design Engineer. Patterson has long experience in airborne hydraulics, particularly in relation to jet engines.

Before joining Vickers in 1955, he spent seven years at Wright Aeronautical Division of Curtiss-Wright Corp., five of them in the turbojet accessories and control department.

GERALD M. HENRIKSEN has been appointed Director of Engineering of Acoustica Associates, Inc., Mineola, Long Island.

Henriksen recently resigned the position of Director, Research and Engineering, Turbo Division of American Machine and Foundry Co. Prior to his AMF position, Henriksen was associated with Marquardt Aircraft Co., The Ames Laboratory of The Atomic Energy Commission, and the Automatic Washer Co. At Acoustica, he will supervise the company's engineering activities on the Atlas ICBM Program, and developments in the fields of ultrasonic cleaning and processing.

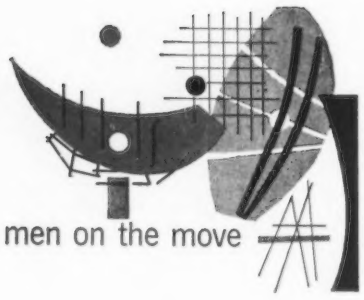
ZEKE R. SMITH has been elected vice president of Potter & Brumfield, Inc. Smith, formerly chief engineer, has been assigned the duties and title of Director of Engineering.

He will be in charge of all product and applications engineering for P&B's three plants located in Princeton, Indiana; Franklin, Kentucky; and Laconia, New Hampshire.

A member of the Executive Staff, Mr. Smith has been associated with Potter & Brumfield, a subsidiary of American Machine & Foundry Co., for the past three and a half years.

Prior to joining P&B, he was associated with Bendix Aviation Corp., Vendo, and Airborne Instrument Laboratory.

Continued on next page



CHARLES VILLIERS, designer and research engineer, has joined the staff of the Electronics Dept. of Hamilton Standard, division of United Aircraft Corp., Broad Brook, as a project engineer.

Villiers has been with U. of Cal. Radiation Laboratory, Eclipse-Bendix, and North American.

Prior to the war, he designed, produced, and flight tested complete airplane engines bearing his name. In 1926, he was responsible for the original design for Sir Malcolm Campbell's world's record Blue Bird racing car. Villiers is a former president of the American Rocket Society.

HARRY SANDERS, Vice Admiral USN (Retired), has joined Chance Vought Aircraft, Inc., as staff engineer-missiles.

He will direct preparation of training material to teach Navy sub crews operation of Regulas II, 1000-miles-plus range missile with a speed beyond Mach 2, now being readied for nuclear missile subs such as the USS Halibut, currently under construction.

Earlier, as Assistant Chief of Naval Operations for Fleet Operations and Readiness, he formulated and issued the Navy's operational requirements for all new weapons systems, including all Navy missiles. As a member of the Ship's Characteristics Board, Sanders helped work out the characteristics of nuclear subs and their missile armament.

ARTHUR R. COLLINS, general manager of the South Wind Division of Stewart - Warner Corp. at Indianapolis, Ind., a post he has held since 1948, has been elected a vice president of the parent company. He will continue to serve as general manager.

Collins started as an engineer in the company's heating equipment department in 1942. In 1943, when the South Wind Division was created for production of aircraft and vehicle heating equipment, he became head of manufacturing and engineering at the Indianapolis plant.

L. D. REXROAT has been appointed Head of the Contracts Department of Haller, Raymond, and Brown, Inc., of State College, Pa., a division of Topp Industries, Inc.

He will be concerned with top level liaison between future and present HRB contractors, and will supervise the operations of the Contracts Administration and Customer Relations sections.

Prior to joining the Topp organization, Rexroat was located in Dayton, Ohio, as Regional Manager for the Philco Corp. In 1957, he was appointed Midwestern Sales Manager in the Dayton office of Topp Industries, Inc.

G. T. WILLEY, corporate vice president of manufacturing, for the Martin Co., has assumed additional duties. He is vice president and general manager of a new division created to speed on-the-spot arrangements for launching both the Navy Vanguard Earth Satellite and the Air Force Titan Intercontinental Ballistic Missile.

Willey is in charge of all Martin activities in the Patrick Air Force Base and Cape Canaveral area, including the continued testing of latest versions of the USAF Matador Tactical Missile.

ARTHUR R. COLLINS
Stewart-Warner

L. D. REXROAT
Haller, Raymond, and Brown

G. T. WILLEY
Martin

industry notes

No Rivalry Here

Defense units to be installed at launching sites by the Army for protection of certain military bases and industrial centers against air attack will use the Talos missile. Talos was developed by Johns Hopkins University and produced by Bendix Corp. for the Navy. It

A Talos ground-to-air missile stands poised for action at Army defense unit

is now an operational shipboard missile. Joint use of identical missiles and warheads by Army and Navy in this surface-to-air missile is one of several economy moves taken by the Armed Forces. These actions have been little publicized in the current discussions on interservice rivalry.

The Air Force also uses a Navy-developed missile, the infra-red homing Sidewinder. Sidewinder is an operational air-to-air missile built by Philco Corp. and General Electric Co.

Hydromatics Moves To New Plant

Hydromatics, Inc. has moved from Cedar Grove to a new plant at 70 Okner Parkway, Livingston, N. J. The new 15,000 sq-ft plant makes possible a four fold increase in production capacity. The company's high performance valves are used on many major missile projects such as Vanguard, Atlas, Titan, and Jupiter.

No Second Prize in Earth Satellite Race

Here is an article which was printed in the November issue of *Magnesium*, the magazine of Brooks and Perkins, Inc. It was written by the firm's president, Howard Perkins.

On Saturday the 26th day of October, Sputnik's voice gave out.

From Russia, they tell us that we will no longer hear its transmission. Its power source is exhausted.

Whether or not we ever hear from it again is of no particular importance.

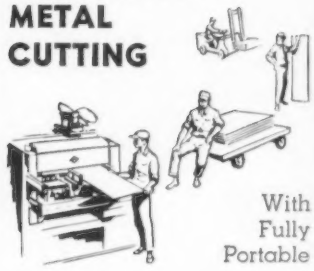
The great, simple, stark fact of Sputnik's existence is all that counts. That alone must have a profound effect on the thoughts and plans of the Western world.

Flashed on the screen of the heavens, the Russians have given to our planet a cleanly delineated picture of their capabilities. Here we are seeing positive proof of their advanced technology, also the excellence of their manufacturing abilities.

Only a fool can say "so what"? No responsible man can possibly be indifferent to the existence of a situation so simply and so dramatically presented. Those who would minimize this thing are doing the West the gravest disservice.

Perhaps we aren't in a race with anyone. If so, it might

FREE PRODUCTION WORKERS FROM STATIONARY METAL CUTTING



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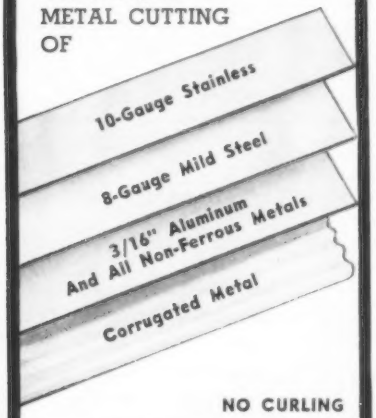
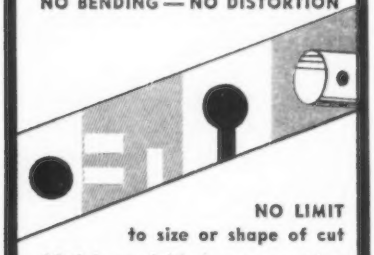
NIBBLERS

ON THE JOB METAL CUTTING OF



NO CURLING
NO BENDING — NO DISTORTION



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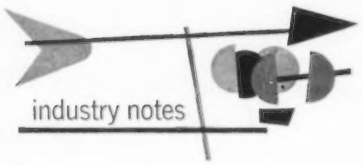
Circle 78 on Inquiry Card, page 81



be well for us to convince the other runner, since in this track meet he has just passed us in one of the very important events—and when the final one has taken place, there won't be any prize for second place.

As a scientific achievement, we must admire Sputnik's birth. We should be duly grateful to the Russians for providing us with such an accurate means for appraisal of their competence. We should take grim warning when any power combines proven capabilities of this magnitude with intentions as coldly hostile as those so frequently reiterated by International Communism.

Consider for a moment, against the somber Russian background, the greatness of this accomplishment. Only 25 years ago, hundreds of American engineers were in Russia, trying to teach to a backward nation of awkward peasants the basic fundamentals of the simpler and heavier types of industry. We well remember the numberless tales told by these engineers of the almost unbelievable difficulties and delays they encountered.

Since that relatively recent day, Russia has withstood wave after wave of awful purges, years of near starvation, the ravages of a great war of invasion. Then came the enormous task of rebuilding a shattered nation and creating, almost from scratch, a new technology on her own.

Consider the amount of drive, and power, and self-generated ability it has taken to lift this backward nation from its abject condition of two or three decades ago. Its present proven superiority in even one scientific field should shock us into a better use of our talents.

The race isn't lost. But, please, let's not say there is no race.

Instead, we must realize that the defense of the West is our *one* matter of supreme priority. Without that, the soundest currency system—the highest standard of living—and the world's greatest concentration of wealth become merely the same sort of tempting prizes that have drawn the predatory hordes since the dawn of history.

Niobium Investigated for Uses in Jets, Missiles

Niobium, a high temperature metal capable of enduring a sustained temperature of 2200°F in alloyed form, is receiving increased attention in the missile field.

In a move to increase progress in establishing forging, rolling, and casting techniques, DuPont and Thompson products have united in a joint development program.

The interest in niobium stems from studies which show it might increase operational temperatures of turbine buckets 500°F above present limits.

Pure niobium oxidizes rapidly at high temperatures, but by alloying this serious deficiency has been partially overcome.

Niobium alloys also show promise as a structural metal for use in nuclear reactors because it has a low "neutron cross section."

Originally called columbium, the pure metal is also being evaluated by Westinghouse. The serious shortcomings of many of the existing high-temperature alloys in meeting present and anticipated demands in the missile field spurs the search for new materials.

missile hydraulic problems

hydraulic components accorded important role at 7th annual aircraft hydraulic conference, sponsored by Vickers Inc., in Detroit.

by Joseph Geschelin, Technical Editor

Hydraulic components for missiles were accorded an important role in the program at the 17th Annual Aircraft Hydraulic Conference sponsored by Vickers Inc., in Detroit.

Specialists representing domestic and foreign airframe manufacturers, airline operators, the U. S. Air Force, and the Bureau of Aeronautics were in attendance for open discussions and prepared technical papers dealing with current problems in hydraulic systems.

Some of the major areas of discussion were:

- Special methods for controlling fluid contamination, particularly problematic in high performance aircraft and missiles.
- Space and weight saving pumps and actuators.
- Hydraulic components for use near 1000°F.
- Special applications for hydraulics in unmanned aircraft and missiles, where removal of landing gear, landing flaps, dive brakes, canopy, etc., have reduced the size of the hydraulic systems.
- Hydraulic system design for a high performance aircraft: the French Caravelle.

Contamination

One of the major problems in hydraulic systems, particularly in high performance aircraft and missiles, is that of contamination control. This was discussed in detail by J. H. Boucher of Chance Vought Aircraft with particular reference to contamination studies on Cutlass and Crusader for the Navy. Out of this study came the "filter patch test" as a service inspection procedure.

Along with the demands of higher operating temperatures go synthetic fluids, metal seals, lapped fit seals, coolers, and the like; most of these increase contamination problems. The author reported that "boot strap" reservoirs are coming into wider use; the objective being to reduce the risk of air leaking into the fluid system during shutdown.

Part of the answer to freedom from contamination was given by Arthur Billet of Vickers in describing the continuing research program on clean pumps for clean systems. The goal is to produce pumps that are clean before they are installed in missiles or aircraft systems. Although various techniques are being studied to insure "cleanness," the most promising is the "filter patch test" described by Boucher.

New Developments At Vickers

One of the sessions was devoted to some new developments at Vickers. One example is the line of oil-cooled motor-pumps, the first production unit being built for the Lockheed Electra. This is a 12-hp oil-cooled unit weighing 31¼ lb, 20 in. long, and has a motor diameter of less than four inches. The oil-cooled unit is smaller and lighter than an aircooled unit of comparable rating and is purported to have the additional advantage of eliminating the duct work in the airframe normally needed for cooling the electric motor.

Another new device is the "spacemaster" servo valve. It is a two-stage, light weight, electro-hydraulic servo valve about 30 per cent lighter than competitive valves. It is intended for missiles and aircraft.

High temperature hydraulic actuators too are new in the Vickers line. Some aircraft and missile applications now call for operation at 1000° F. Depending upon the temperature range, Vickers employs either titanium or a combination of titanium and high strength stainless steel in these components.

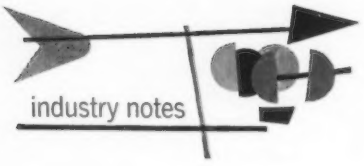
A new miniature vane pump has been developed primarily for missiles applications where fluid pressures are below 1000 psi. The pump delivers one gpm at 9300 rpm and 1000 psi. It is small and light weight, simple and inexpensive to produce.

What Hydraulics Can Do

In a summary of "What Hydraulics Can Do," Frank L. Moncher, of Vickers, outlined the numerous current applications and touched on the use of hydraulics in the expanding missiles field. The necessity for high performance and reliability coupled with tight space restrictions in missiles dictates the use of hydraulic "muscles" to execute the commands of the electronic guidance "brain." A typical packaged system supplies hydraulic power for flight controls and fuel tank pressurization; it includes—an accumulator, reservoir, and the necessary controls.

Caravelle System Design

A description of the hydraulic system of the French Caravelle commercial airplane, which features fully powered flying controls, was given by



Robert Blanchet of Sud Aviation Corp. He noted that the requirements of simplicity and standardization were satisfied by using fittings, valves, hoses, etc., made to American AN standards; the fluid used is a mineral base oil to French Specification FHS 1, which is equivalent to MIL-0-5606.

The Caravelle hydraulic system is composed of four sections, each identified by color. The *green*, or primary normal system, has its own reservoir and two engine-driven pumps, one on each engine. It services the landing gear, nose wheel steering, wheel brakes, wing flaps, air-brakes, passenger ramp, and one side of the flying control servodyne tandem actuators. Operating pressure is 2000-2500 psi.

The *blue*, or secondary normal system, also has its own reservoir and two pumps. It services the second side of the servodynes and the artificial feel device. Both green and blue systems are continuously and simultaneously in operation.

The *yellow* stand-by system has an electrically driven hydraulic pump which draws fluid from either the green or blue reservoirs. It services, in emergency, either side of the servodynes and the artificial feel device.

The *red*, emergency system, has its own reservoir and has an electrically driven hydraulic pump for servicing the landing gear, wheel brakes, and wing flaps. A two-stage heavy duty pump, incorporated in the red system, serves as a stand-by in the event of electrical failure.

Cermets in Russian ICBM?

In connection with its claims of possessing an inter-continental ballistics missile the Soviet Union has announced the attendant heat problems are handled by using liquid cooled "metallo-ceramics" (cermets).

A recently published article by Major V. Parfenov of the Soviet Engineering Corps stated that Russia had abandoned the use of exotic metals and turned to fire resistant porous ceramics containing 10 to 20 per cent cobalt powder. Liquid is forced through the cermets at high pressure, the resultant evaporation is purported to cool the missile structures to tolerable limits.

Use is made of this material in the combustion chamber and the jet exhaust nozzle of the Russian ICBM.

This has led to some speculation here that the same method of handling the troublesome re-entry heating problem for ICBM nose cones may be under investigation by Russia.

Unshaken U. S. metallurgists state that the cobalt cermets have been under study in this country for some time but are considered too heavy for use in long range missiles.

Eight Reasons for Russia's Technological Success

by Richard E. Stockwell

"The thing we worry most about is the possibility of technological surprise with a new weapon. The balance now of qualitative superiority in our weapons is such that I think the international situation could be changed dramatically if such an incident were to occur."

That statement was made before a congressional committee in 1955, and in view of relatively recent events, it was prophetic. However, I doubt that Lt. Gen. Donald L. Putt, USAF's Deputy Chief of Staff for Development, gets any satisfaction out of being a prophet on such a gloomy subject.

How did the Russians do it? How did they beat the most advanced nation in the world to an ICBM and an earth satellite —or, for that matter, to a jet transport?

It is worthwhile to study their technique, insofar as we can. It should be clear to most everyone by now that there are some things we can learn from the Russians.

What follows are eight reasons why I believe the Russians, considering the problems that faced them, have had such remarkable success.

Attitude

The Communists, who run Russia, have a definite goal and purpose. To achieve it they saw the need to greatly strengthen their military arm, which proved lacking in so many ways in World War II. It was clear to them that if they were to get ahead in weapons, they must leap-frog in front of the West by achieving one or more major technological advances.

Decision-Making

It is a part of communist doctrine to retain the initiative wherever possible, and this applies as fully to technology as to political questions. Thus, the broad outlines of their program to build up their air power—a program begun in 1945-46—now can be seen reaching fulfillment 10 years later. They also made the decision at the same time to push the development of missiles. Russia has been will-

ing and anxious to gamble completely on scientific and engineering research.

Project Selection

Instead of scattering their shots over the entire spectrum of possibilities, Russia carefully concentrated its research and development efforts on a limited number of projects that promised both immediate and long-range payoff.

Simplicity

The Russians tend to design and build things as simply as possible, even to the point where they are willing to take small reductions in performance. Everything on their aircraft and missiles is functional. No designer's time is put into appearance; no production time goes into a finished surface when it isn't essential.

The RD-45 turbojet engine that went into the MiG-15 jet fighter was built so that only one part needed to be replaced during its lifetime in the field. After the engine had been flown a prescribed number of hours, it was ready for overhaul and was returned to the factory.

Similarly, the AM-3 engine, which the writer was fortunate enough to see recently, and which powers the Tu-104 Russian jet transport, follows British practice of using open ports (between the third and fourth compressor stages) to eliminate stalling. To open and close the ports, a very simple design is used. A thin steel band around the outside of the engine is tightened by a hydraulic piston when the pilot wants to close the ports. Releasing the piston uncovers the ports. Simple, but effective.

By a concerted drive to achieve simplicity, the Soviets save manpower, materials, machinery, and plant facilities—and so are able to get more done with less effort, albeit at some cost in refinement, appearance, and sophistication.

Standardization

In Russia the same clock is used in automobiles as in the cabins of commercial aircraft. Many parts on jet transports are identical with those found on jet bombers. An outstanding example of standardization is the Russian assertion that the same first stage rocket is used for both the ICBM and earth satellite.

Education

Russian progress in education has had great implications in the past, but even more for the future. They began an intensive drive in 1928 to train more scientists and engineers, and except for World War II, the program has never stopped. Such studies as sociology and economics, which attract a great many students in other countries, are played down in the USSR.

When an emphasis is put on mathematics, biology, physics, chemistry, geology and related subjects during primary and secondary school training, it tends to direct into scientific and engineering pursuits more of the students who go on to higher centers of learning. Since the Russians today are training such people about twice as fast as the U. S., it is clear that they are out to gain an even greater technological lead over us in the future.

A visit to the Physics Faculty of Moscow University this past summer has convinced the writer that it would be utter folly to discount the quality of Soviet training. Comparison of the mechanical engineering course in Russia with the course in the United States indicates quite clearly that Soviet training is more intensive, with less cultural subjects and more basic material.

Secrecy

Vast parts of Russia are closed to foreign visitors; most plants are surrounded by high walls and do not carry signs to identify them. Critical defense areas are hidden on country roads.

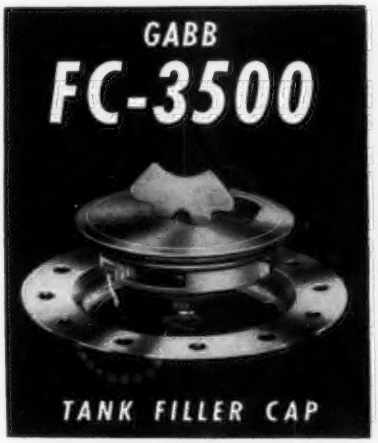
By keeping from the rest of the world just what they were concentrating their efforts on and at what rate, they have given themselves a great strategic advantage.

Foreign Technology

When it comes to technical information, all roads seem to lead to Moscow, and only a tiny trail leads out of Moscow toward the West.

The Russians garner to themselves everything that might be useful in the way of foreign technology, military, and political information. The Academy of Sciences in Russia operates a special Scientific Information Institute in Moscow. It reviews several thousand periodicals and books from the U. S. each year. Abstracts of

Continued on page 100



The Model FC-3500 is the first tank filler cap to successfully pass all test requirements of MIL-C-7244B (ASG) applicable to fuel, oil, alcohol-water and hydraulic reservoirs.
Lever action design permits cap to be opened safely under pressure and removed completely with only a 35° turn. Now available in 1.5, 2, 3, and 3.82" openings.

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GABB SPECIAL PRODUCTS Inc.
WINDSOR LOCKS, CONN

Circle 79 on Inquiry Card, page 81

(*Continued from page 80*)

applicable to the production of close-tolerance intricate patterns in metal strip or sheet stock. Listed in this bulletin are such applications as filters, strainers, dials, cams, pointers, linkages, gears, and diaphragms.—Superior Tube Co.

Circle 159 on postcard for more data

Pressure Switch

Electroset pressure switch is introduced by Bulletin 1570. This switch automatically adjusts itself to close at an applied pressure when a solenoid circuit is momentarily energized. After the solenoid is reenergized, the switch will always close at the same pressure until the solenoid is again operated. Since no mechanical connection to the switch is required, the entire mechanism can be hermetically sealed in an evacuated case. Applications, performance characteristics, and dimensional outline are included. — Trans-Sonics, Inc.

Circle 160 on postcard for more data

Suggestion Form

A new self-mailing suggestion form is introduced to facilitate submittal of suggestions without use of customary suggestion boxes. System is designed to encourage companies, who do not presently have suggestion systems, to adopt this simplified self-mailing method which requires no additional manpower.—UARCo Inc.

Circle 161 on postcard for more data

Wing-Nuts

Two new fasteners are described by detail specification sheets. One, the capped wing-nut, is provided with a closed threaded section to protect bolt ends, and offers decorative finish. The other, a washer base wing-nut, is designed to reduce assembly and storage problems. Fits for both styles are NC-2 and NF-2. — Gries Reproducer Corp.

Circle 162 on postcard for more data

Force Control Switches

A new 2-page bulletin describes complete line of force control switches designed to control mechanical forces electrically. Complete specifications and prices are included. Designed for tension or compression applications, these switches are available in six capacities: 0 to 100, 1000, 5000, 10,000, 25,000 or 50,000 lb.—W. C. Dillon & Co.

Circle 163 on postcard for more data

Pulse Modulator

A new Model 63M high-voltage hard-tube pulse modulator is announced. The unit is a flexible tool for experimental tube testing. It is capable of three distinctly different modes of operation: Cathode pulsing, modulating-anode pulsing, and grid pulsing. In all modes, it operates anywhere in the range from 30 to 12,000 cps with pulse lengths continuously variable from .5 to 30 microseconds.—Levinthal Electronic Products, Inc.

Circle 164 on postcard for more data

Sieve Shaker

A new four-page bulletin describes the Dynamic Sieve Shaker applicable to sifting or grading of sand, gravel, aggregates, chemical powders, plastics, powdered metal, bearings, and similar granular or powdery substances. The new shaking pattern rotates the sieve platform in a circular arc while it is also being swayed in a vertical arc. An impact is also imparted to the platform six times per revolution.—Soiltest Inc.

Circle 165 on postcard for more data

Milling Machines

A line of new tracer-controlled sculpture-milling machines is described in four-page bulletin CRS-57. Specifications, features, and uses of these machines in aircraft and die work are featured. Milling speeds and feeds are also given.—Colonial Broach & Machine Co.

Circle 166 on postcard for more data

Fork-Lift Trucks

Potential purchasers of electric fork trucks can now evaluate various types and models of electric fork-lift trucks through a newly available comparison chart. It enables users to survey simultaneously the operating, design, and maintenance characteristics of three different trucks. Included are turning radii, lifting and lowering speeds, fork elevations, collapsed height, type of controls, capacity, and braking system.—Lewis-Shepard Products, Inc.

Circle 167 on postcard for more data

Special Fasteners

Engineering data on a full line of special fasteners is provided in a new condensed eight-page catalog. Dimensional drawings, specifications and important features are shown for the Link-Lock, Hinge-Lock, Spring-Lock, Quick-Lock, Roto-Lock, and Dual-Lock fasteners.—Simmons Fastener Corp.

Circle 168 on postcard for more data

Springs

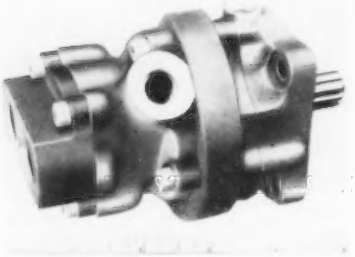
Recently published bulletin furnishes useful spring design data for engineers and designers. A glossary of spring terms, data table, and spring application diagrams is included.—Hunter Spring Co.

Circle 169 on postcard for more data

Continued from page 79

Cryogenic Pump Developed To Handle Liquid Nitrogen

A compact, light-weight, piston-type pump has demonstrated capability for pumping liquid nitrogen at pressures of over 3000 psi at speeds of over 3500 rpm. The pump has nine axial pistons, and is of the fixed



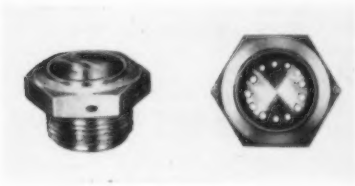
displacement type. Metal parts have been selected to be compatible with liquid nitrogen. Minor material changes can be incorporated to permit satisfactory operation using liquid oxygen.

Sundstrand-Denver

Circle 130 on postcard for more data

Oil Level Inspection Cap Has Transparent Window

Fluid level sight glass shows the presence of liquid by a reflecting surface located behind the transparent window. It is designed for applications that require quick visual inspection. The inspection window can



be used to show the presence of oil in gear cases or to indicate liquid level in other types of housings. Installation of the sight glass requires only a suitable tapped hole.

Technical Development Co.

Circle 131 on postcard for more data

Continued on page 99

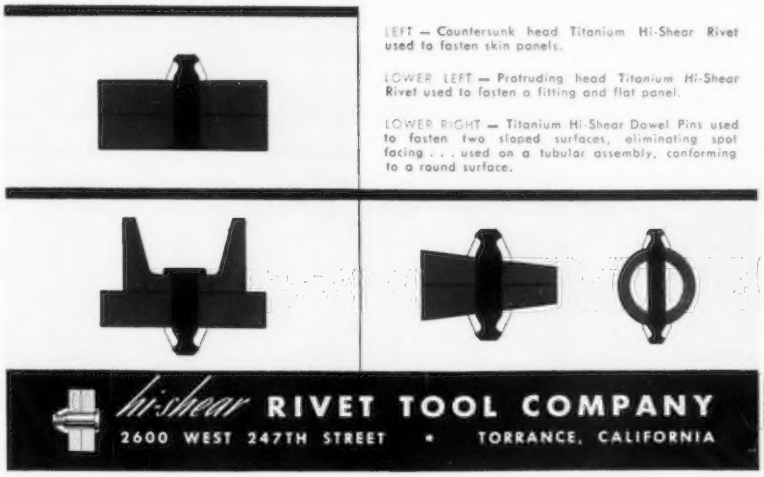
A REMARKABLE SAVING IN WEIGHT WITH NO LOSS IN STRENGTH

Boeing's B-52 Intercontinental Jet Bomber of the USAF's Strategic Air Command gives this nation a retaliatory weapon capable of carrying out nuclear strikes anywhere in the world. Speeds beyond 650 mph, altitudes in excess of 50,000 feet and an unlimited range with refueling, make the B-52 one of the most powerful weapons in recorded history.

Titanium Hi-Shear Rivets are being used extensively in the B-52 and have trimmed hundreds of pounds from the total weight of the airplane. Weight savings of this nature mean longer range, greater speed and better overall airplane performance.

Hi-Shear Rivet Tool Company is now producing Titanium Rivets in large production quantities and a full range of sizes. A comprehensive test program has indicated the fine physical characteristics of this fastener, insuring the continued high precision quality of the Hi-Shear Rivet in this new material.

Write in for details and information on this and other Hi-Shear fasteners.

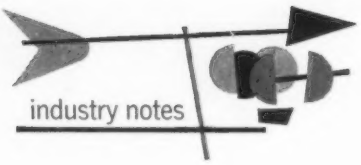


LEFT — Countersunk head Titanium Hi-Shear Rivet used to fasten skin panels.

LOWER LEFT — Protruding head Titanium Hi-Shear Rivet used to fasten a fitting and flat panel.

LOWER RIGHT — Titanium Hi-Shear Dowel Pins used to fasten two sloped surfaces, eliminating spot facing . . . used on a tubular assembly, conforming to a round surface.

hi-shear RIVET TOOL COMPANY
2600 WEST 247TH STREET • TORRANCE, CALIFORNIA



INDUSTRY STATISTICS

Source: Bureau of the Census and Civil Aeronautics Administration.

MANUFACTURERS' NET SALES OF COMPLETE AIRCRAFT, AIRCRAFT ENGINES, AND PROPELLERS

All data in Millions of Dollars

Product	1957 First Quarter	1957 Second Quarter	1957 6 Months Total	1956 First Quarter	1956 Second Quarter	1956 6 Months Total
Complete Aircraft and Parts						
For U. S. Military Customers	$1,241	$1,426	$2,667	$ 821	$ 965	$1,786
Other Customers	261	326	587	415	702	1,117
Total—Aircraft and Parts	$1,502	$1,752	$3,254	$1,236	$1,667	$2,903
Aircraft Engines and Parts						
For U. S. Military Customers	$ 501	$ 527	$1,028	$ 454	$ 856	$1,310
Other Customers	97	106	203	397	76	473
Total—Engines and Parts	$ 598	$ 633	$1,231	$ 851	$ 932	$1,783
Aircraft Propellers and Parts						
For U. S. Military Customers	$ 22	$ 30	$ 52	$ 18	$ 33	$ 51
Other Customers	12	12	24	14	20	34
Total—Propellers and Parts	$ 34	$ 42	$ 76	$ 32	$ 53	$ 85
Total—U. S. Military Customers	$1,764	$1,983	$3,747	$1,293	$1,854	$3,147
Total—Other Customers	370	444	814	826	798	1,624
Other Products and Services	535	588	1,123	390	502	892
Total—All Products	$2,669	$3,015	$5,684	$2,509	$3,154	$5,663

TOTAL HP. OF AIRCRAFT PISTON ENGINE SHIPMENTS FOR CIVILIAN USE

Month	Total Hp. (In thousands) 1957	Total Hp. (In thousands) 1956	Avg. Hp. per Engine 1957	Avg. Hp. per Engine 1956
January	604.4	383.3	657	412
February	647.0	401.3	717	411
March	679.2	431.7	672	405
April	668.2	431.4	703	455
May	715.8	503.5	702	485
June	730.4	459.4	783	470
July	590.4	444.6	737	446
August	425.6	431.8	548	416
September	482.8	481.0	663	607
October	628.3	536.0	661	594
November	...	556.6	...	611
December	...	595.6	...	644
Total		5,656.2		492
Total—10 Months	6,172.1	4,504.0	686	...

SHIPMENTS OF PISTON ENGINES FOR CIVILIAN AIRCRAFT

Month	Units 1957	Units 1956	Value 1957	Value 1956
January	920	930	$ 12,445,000	$ 6,800,000
February	902	976	13,596,000	6,923,000
March	1,010	1,065	13,975,000	7,600,000
April	950	949	14,388,000	7,967,000
May	1,020	1,038	15,160,000	9,459,000
June	933	977	15,636,000	8,682,000
July	801	996	12,748,000	8,420,000
August	776	1,037	8,603,000	8,036,000
September	728	793	10,150,000	9,938,000
October	951	902	13,638,000	10,677,000
November	...	911	...	11,391,000
December	...	925	...	12,370,000
Total		11,499		$108,263,000
Total 10 Months	8,991	9,663	$130,339,000	$ 84,502,000

CIVIL AIRCRAFT SHIPMENTS AND AIRFRAME WEIGHTS

Month	Units 1957	Units 1956	Value 1957	Value 1956	Thousands of Pounds 1957	Thousands of Pounds 1956
January	584	537	$48,431,000	$22,325,000	1,574.9	986.2
February	523	614	49,278,000	32,139,000	1,554.0	1,265.4
March	665	656	46,465,000	29,562,000	1,615.6	1,200.4
April	642	692	57,723,000	30,229,000	1,871.6	1,227.1
May	662	714	83,965,000	35,145,000	2,548.0	1,362.2
June	580	648	69,326,000	40,270,000	2,104.0	1,460.8
July	515	507	70,480,000	32,280,000	2,086.0	1,162.3
August	509	681	62,825,000	46,294,000	1,940.6	1,600.7
September	456	613	54,745,000	41,137,000	1,628.1	1,389.2
October	464	508	45,522,000	50,089,000	1,448.6	1,583.6
November	...	472	...	51,518,000	...	1,550.7
December	...	563	...	43,168,000	...	1,413.7
Total		7,205		$454,156,000		16,202.3
Total—10 Months	5,600	6,170	$588,760,000	$359,470,000	18,371.4	13,237.9

UNFILLED ORDERS OF AIRCRAFT FOR CIVILIAN USE

Month	Aircraft 1957	Aircraft 1956
January	997	802
February	992	820
March	985	841
April	966	867
May	947	959
June	900	988
July	854	1,015
August	808	998
September	783	1,010
October	757	1,028
November		1,022
December		1,014

SHIPMENTS OF PROPELLERS

for Civilian Aircraft

Month	Number of Propellers 1957	1956
January	1,148	1,060
February	1,403	1,014
March	1,629	1,199
April	1,475	1,196
May	1,572	1,273
June	1,419	1,375
July		979
August		947
September		1,035
October		1,097
November		974
December		808
Total		12,957
Total—Six Months	8,646	7,117

SHIPMENTS OF AIRCRAFT PROPELLERS AND PARTS

All data in Thousands of Dollars

Period	Total All Products	For Military Aircraft	For Civilian Aircraft	Other Products†
1957				
First Quarter	$51,079	$20,767	$11,599	$18,713
Second Quarter	60,772	27,065	11,483	22,224
Total—Six Months	$111,851	$47,832	$23,082	$40,937
1956				
First Quarter	$40,343	$21,520	$ 6,430	$12,393
Second Quarter	45,014	21,639	7,837	15,538
Total—Six Months	$85,357	$43,159	$14,267	$27,931
Third Quarter	$40,502	$17,835	$ 7,744	$14,923
Fourth Quarter	59,939	26,217	9,766	23,956
Total—Twelve Months	$185,798	$87,211	$31,777	$66,810

† Includes experimental.

BACKLOG OF ORDERS FOR COMPLETE AIRCRAFT, AIRCRAFT ENGINES AND PROPELLERS

All data in Millions of Dollars

Product	June 30, 1957	June 30, 1956	Dec. 31, 1956
Complete Aircraft and Parts			
For U. S. Military Customers	$ 7,473	$ 8,524	$ 8,841
Other Customers	2,893	2,724	2,907
Total—Aircraft and Parts	$10,366	$11,248	$11,748
Aircraft Engines and Parts			
For U. S. Military Customers	$ 2,809	$ 3,231	$ 3,316
Other Customers	706	654	749
Total—Engines and Parts	$ 3,515	$ 3,885	$ 4,065

Product	June 30, 1957	June 30, 1956	Dec. 31, 1956
Aircraft Propellers and Parts			
For U. S. Military Customers	$ 149	$ 110	$ 146
Other Customers	39	42	45
Total—Propellers and Parts	$ 188	$ 152	$ 191
Total—U. S. Military Customers	$10,431	$11,865	$12,303
Total—Other Customers	3,638	3,420	3,701
Other Products and Services	2,235	1,907	2,346
Total—All Products	$16,304	$17,192	$18,350

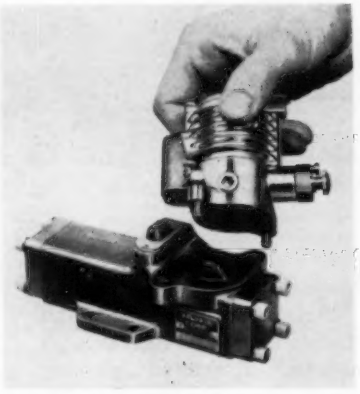
Continued from page 97

Quick Connect 4-Way Valves Have Built-In Electrical Plugs

A complete line of Speed King plug-in type ¼-in. four-way control valves, featuring built-in plug connectors for fast, automatic connection to electrical circuits is now available from the producer.

Said to reduce original installations and in-service maintenance time to an absolute minimum, plugs and connectors incorporated in solenoid pilot, and valve body, complete all electrical circuits automatically when the unit is placed in mounting position. The plug-in feature also permits economical bench assembly of complete control groups, and cuts final machine assembly time.

The valves are made of Navy M bronze bodies, stainless steel and caps, hard chrome plated stainless steel stems, and



standard Speed King O-ring packers.

Pilot plungers and valve stem are the only moving parts and no springs are used in the main valve body. Coils, encased in molded epoxy resin, are guaranteed against burn-out for the life of the valve. Service life is said to exceed 25 million cycles.

Valvair Corp.

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	Page
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Cornelius Co.	79
Federal Products Co.	11
Fenway Machine Co.	92
Gabb Special Products	95
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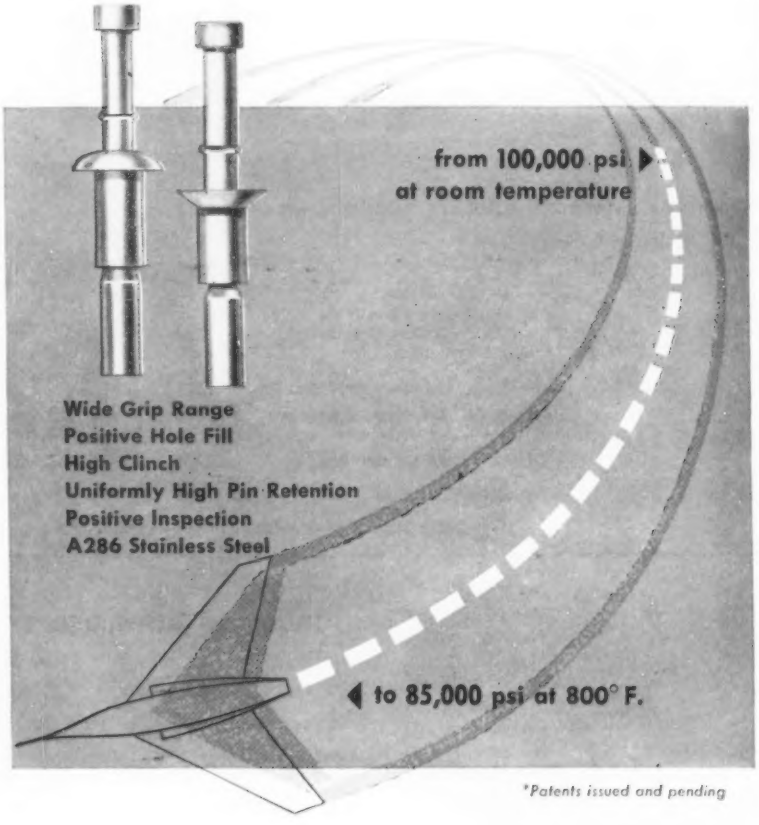
for Hi-Strength at Hi-Temperature the Cherry "600" Rivet*



*Patents issued and pending

To meet the design requirements imposed by extremely high-speed aircraft and missiles, the Cherry Rivet research and development department has introduced the "600" A286 stainless steel blind rivet.

Data on the strength capabilities of the "600" rivet is available from Townsend Company, Cherry Rivet Division, P.O. Box 2157-DD, Santa Ana, Calif.

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Continued from page 95

items of interest to Soviet scientists and engineers are sent throughout the country. Translations of any article may be had by writing to the Institute.

Libraries in all major cities (there are some 350,000 libraries in Russia) provide translators for qualified people to have books and magazine articles translated. In addition, every research institute and major industrial plant has its own library and translators who call to the attention of key people whatever is important in the foreign press. In the U. S. alone they spend an estimated $200,000 a year on technical and scientific literature.

More Power Packs For C-123 Provider

A third extension order for power packs (engine assemblies) for the Fairchild C-123B Provider troop transport plane has been received by Temco Aircraft Corporation.

The additional order, totalling approximately $500,000, will carry work on the assembly through March 1958.

Temco assembles all electrical and hydraulic components, propeller controls, fuel controls, and nacelle housings for installation around Pratt and Whitney R-2800 engines. The power package is then sent to the Fairchild Aircraft Corp. plant at Hagerstown, Md.

The Provider, with a crew of two, will airlift and land 60 equipped troops on short, unimproved runways. The plane also can be used to airlift artillery, heavy trucks, or other support equipment.

The two P&W 2500 hp piston engines give the Air Force plane a range of 1340 mi with 19,000 lb of cargo, or 2440 mi with 12,000 lb.

SCIAKY

HELPS PUT PROFIT
INTO MANUFACTURING

Heintz Achieves Volume Production with New Sciaky Counter Control Welders

In fabricating and job shops, where a wide variety of assemblies must be welded to rigid specifications every day, Sciaky resistance welding helps keep production schedules *on schedule*.

The Jet Engine Division of the Heintz Division, Kelsey-Hayes Company, a large Philadelphia contract fabricator, manufactures original and replacement parts for the aircraft industry. This means their production must meet exacting jet engine specifications.

New Sciaky Counter Control

To help meet these requirements, Heintz now uses Sciaky Patented Three-Phase Resistance Welders with the new Predetermined Electronic Counter Control. This new unit provides precise control of all welder functions for absolute production consistency. All control settings are realized with extreme accuracy, and are readily reproduced at any time to duplicate previous production runs. The machine cannot deviate from its setting.

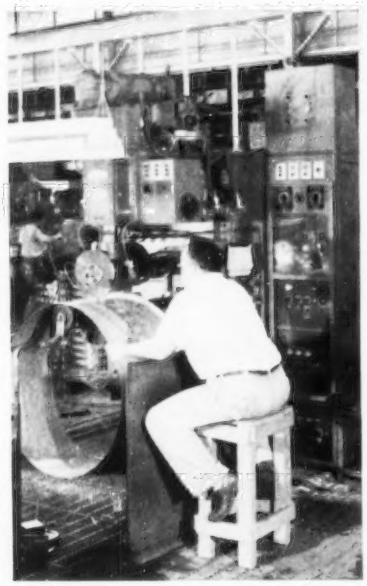

Fig. 1 Seam welding Nimonic to Nimonic on Pratt & Whitney Aircraft J-57 afterburner diffuser section.

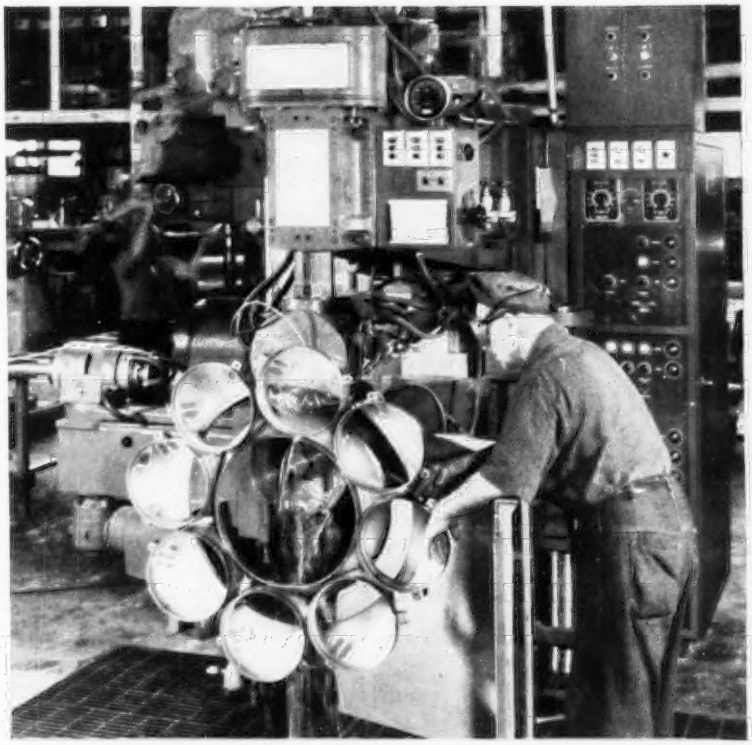

Fig. 2 Seam welding stainless to stainless on Pratt & Whitney Aircraft J-57 jet engine transition duct assembly. Note simple fixture used.

The Sciaky Predetermined Electronic Counter Weld Control is the only control of this type that has been proved in service, and the first unit of this kind has now been in use nearly two years.

How It Works

The Sciaky Predetermined Electronic Counter Control counts the cycles of power line frequency which is governed by the U.S. Naval Observatory. In predetermined absolute numbers, cycles and impulses are simply counted by a Dekatron tube to control the duration of the various welder functions. The absolute consistency of the control eliminates the need for time-consuming periodical check-out or calibration. Plug-in feature permits easy unit replacement, or addition of other control functions if required.

Circle 62 on Inquiry Card, page 81

Operations Performed

Photos show typical Sciaky resistance welding applications on jet engine parts—Afterburners, Screech Screens, Engine Duct Assemblies, etc. Materials welded include Nickel Alloy, Nimonic and Stainless Steel.

Information Available

Case histories outlining the successful use of Sciaky Resistance Welding Techniques on jet engine components are available on request. Specific recommendations will be furnished on receipt of an outline of your requirements.

Write today, mentioning the information you would like to receive. There is no obligation. Sciaky Bros., Inc., 4941 W. 67th St., Chicago 38, Ill. POrtsmouth 7-5600.

62-C

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